Chest *X*-Ray Diagnosis

By

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Affectionately Dedicated

to

MY WIFE FRANCES

AND

MY CHILDREN EDWARD, MARION, AND JOSEPH

PREFACE

THE roentgen method of physical examination is now universally accepted as an important adjunct to the clinical examination of the patient. It is generally recognized that roentgen examination of the chest affords a superior method of diagnosing tuberculosis and many other diseases of the heart and lungs. Wide spread studies for the detection of tuberculosis by use of the x ray began in the 1930 s. At present it is estimated that more than fourteen million people have roentgenograms of the chest each year. Over sixty million individuals in the United States consult a physician annually. Pulmonary and cardiac disease have a higher incidence among this group than in the general population. It would be a great boon if each of these persons who had not recently done so had a routine study of the chest. Many cases of unsuspected disease would be discovered by this means thus enabling the physician to establish the diagnosis and institute the necessary remedial measures much earlier than otherwise would have been possible. Many institutions of higher learning require roentgen study prior to admission and industry also participates in the program by the use of routine pre employment surveys. Roentgen methods permit the study of large segments of the population quickly easily and at relatively low cost in time and money. Sixteen million persons are admitted to hospitals each year. Prompt recognition of tuberculosis and other disease in these individuals is of obvious advantage to the patient hospital personnel and the entire community. Clinicians are beginning to appreciate the importance of a routine roentgen study of every individual. It is our considered opinion that in the near future every person will have chest roentgenograms at intervals of six months to a year as a part of a regular check up study.

Since the data derived from roentgen examination of the chest are of such great importance it is essential for every clinician to have an understanding of the nature value and limitations of the method. The field of medicine has become increasingly wide and complex and as a consequence in recent years there has developed an ever increasing tendency to specialization. In spite of the constant trend toward the division of medicine into separate branches each of which tends as a rule to become increasingly smaller in scope roentgenology is of such

widespread and general interest that it may well be termed the universal specialty and every physician must have a knowledge of this field It is helpful for the clinician to have ready access to sources which will supply this information

The purpose of this book is to describe and discuss the criteria on the basis of which the diagnosis of disease of the lungs and heart can be established by roentgen methods and make available a large varied collection of radiographs which illustrate both the common and rare conditions in which roentgen examination may be of value The potentialities and limitations of the roentgen method of diagnosis are evaluated The material in this presentation has been accumulated from the Department of Radiology of the Boston City Hospital and the private practice of the author and represents an experience of thirty years It is presented to assist the student the practitioner the internist the specialist in diseases of the chest and the radiologist in the roentgen diagnosis of diseases of the lungs and heart

Boston Massachusetts M R

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Fig 9 R Alexander M D Fig 23 J F Sheehan M D Fig 31 C B Favour M D Figs 32 98 105 135 282 283 285 Eastman Kodak Company Fig 54 C C Birkelo M D and W Brosius M D Fig 97 M J Stone M D Fig 104 C A Stevenson M D Figs 142 and 143 F Fleischner M D Fig 179 H H Lerner M D Fig 213 P Massik M D Fig 326 G B Ferguson M D and the Archives of Otolaryngology Fig 330 P L Farinas M D Figs 335 336 and 337 H E Ungerleider M D Figs 208 344 385 and 404 I Steinberg M D and C T Dotter M D Department of Radiology New York Hospital

I have drawn on numerous papers previously published in the medical literature by myself and collaborators and extend my sincere thanks to my co workers and the editors of the journals for their cooperation in the use of material from the following articles

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MAX RITVO, M.D.

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on the roentgenogram are gross in nature. While it frequently is possible to translate the gross manifestations into a microscopic picture, in many instances this is not possible since many different lesions can produce closely similar alterations roentgenographically. For example, there is a very large number of diseases which produce miliary scattered densities in the lungs with almost identical roentgen manifestations. A diffuse pulmonary infiltration can be caused by pneumonoconiosis, sarcoid, yeast or fungus infection, metastatic neoplasm, primary carcinoma of the lungs, bronchiectasis and many other lesions. A



Fig. 1.—Normal Chest, Adult Male

solitary rounded density in the lung field may be due to metastatic tumor, primary carcinoma of the lung, adenoma, tuberculoma, encapsulated fluid, consolidation, hamartoma, lung abscess, arteriovenous aneurysm or infarct. The development of a pleural effusion or massive atelectasis may obscure important underlying disease. A bronchial adenoma or bronchiogenic carcinoma not infrequently produces an area of atelectasis which prevents visualization of the primary tumor. Neoplasm of the pleura or the lung may not be demonstrable because of massive pleural effusion. Mediastinal masses in Hodgkin's disease are often associated with large amounts of fluid which obliterate the enlarged glands.

In arriving at a roentgen diagnosis there are two essentials First the observer must visualize the abnormalities which are demonstrable roentgenographically The changes may be so marked as to be obvious on a cursory survey of the *x* ray film or roentgenoscopic image In other instances a most careful and complete study is necessary before the changes can be detected In every instance both a quick glance and a thorough study are necessary Both are always possible and should be utilized to their fullest extent Having detected the roentgen changes it is secondly essential that the data be properly analyzed in order that

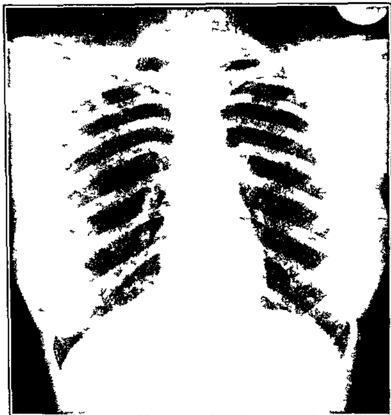


FIG 2 —Normal Chest Adult Female

The mammary shadows cause slight haziness at the peripheral portions of the lower lung fields

a correct conclusion may be reached The degree of success in these procedures is dependent on the training experience and diagnostic acumen of the observer A knowledge of the essential portions of the clinical history physical examination and laboratory findings is an integral part of an adequate roentgen study The identification of a pulmonary lesion is frequently difficult and the roentgen diagnostic procedures must be applied with the same care thoroughness and skill as in all other fields of medicine It is essential that the data obtained from all other diagnostic aids be utilized in association with the roentgen findings

in order that the patient may derive the greatest benefit from this method of examination

In the study of the chest it is no longer considered sufficient to make merely a posteroanterior roentgenogram Routine survey methods while of great value do not uncover many pathologic processes and a host of conditions will be overlooked and the diagnosis not established Even though an intrathoracic abnormality has become of sufficient size and density to be demonstrable on the posteroanterior roentgenogram the radiologist cannot definitely establish its location size shape and nature from this view alone and additional roentgen studies must be utilized in order to obtain this important data The lateral projection is essential in every instance and should be used routinely However it is not always possible in this position to establish the side involved and small soft areas of densities may be obscured by the overlying shadows of the heart great vessel ribs and shoulders Stereoscopic studies in the posteroanterior projection are of the greatest value but do not always permit of accurate study of the retrocardiac area the hila the apices and the extreme bases The oblique positions may afford visualization of portions of the chest which are otherwise obscured and should be used freely whenever necessary Parallax permits of localization and aids in determining the size and shape of intrathoracic densities It is not possible to state which oblique projections should be used routinely although turning the patient through an arc of 20 to 35 degrees usually proves most satisfactory Preliminary roentgenoscopic observations should be carried out and the optimum positions to demonstrate the lesion determined in each case Roentgenograms during inspiration and expiration have proven of value in the demonstration of areas of pneumothorax Studies in the decubitis position may demonstrate small collections of fluid in pleural effusion hydropneumothorax and lung abscess which otherwise might not be visualized Kymography tomography and over exposed films with the Bucky diaphragm will often aid in establishing the diagnosis with definiteness In many cases the roentgen examination requires resort to special studies such as bronchography the ingestion of barium mixtures and the utilization of opaque dyes Follow up studies at intervals of days or weeks are an important aid in diagnosis and in studying the progress of tuberculosis neoplasms and the clearing of pneumonic processes fluid abscess and other pulmonary lesions The radiologist has many tools available to him and must utilize all of them to their utmost capacity in every case

The roentgenoscope is an essential part of the roentgen study In the examination of the chest it is our practice to perform roentgenoscopy first roentgenograms then being made in various projections as necessary in the individual case In mass surveys this is not possible However all doubtful cases discovered during a survey should be recalled for full size roentgenograms roentgenoscopy and other special studies Dependence on fluoroscopic observations alone in the making of a roentgen diagnosis is hazardous as the fluoroscope is definitely inadequate to demonstrate small intrapulmonary lesions Of equal importance is the fact that early disease may be overlooked in the stage when it is curable and a false sense of security result Irreparable harm can be done if reliance is placed on fluoroscopy alone The trained radiologist considers the fluoroscopic observations supplementary to the roentgenograms

Roentgen study has proven its value in numberless ways It is important not only in the establishment of a diagnosis but also in eliminating other diagnostic

processes by roentgenographic study The correct conclusion can be established after roentgen analysis in over 75 per cent of the cases Lesions in the lung as small as 3 to 4 mm in diameter can be visualized and their nature determined in most instances roentgenographically Very small lesions particularly those seated deeply in the lung are obviously not possible of detection by the usual clinical methods In the gastrointestinal tract approximately 80 per cent of the diseases may be shown by roentgenographic study and it is possible to make a correct pathologic diagnosis in practically every instance The introduction of cholecystography has greatly increased the accuracy of roentgen diagnosis and at the present time 95 to 97 per cent of disorders of the gallbladder particularly

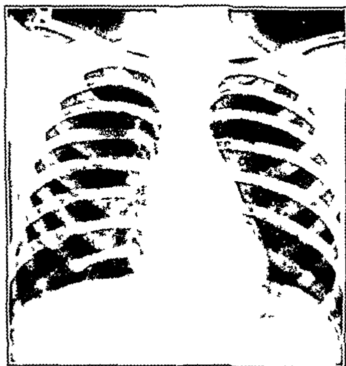


Fig 3 —Normal Chest Child Nine Years of Age

stones can be diagnosed The use of intravenous pyelography permits of a physiologic study of the kidney just as cholecystography permits of the physiologic study of the gallbladder By pyelographic methods it is possible to diagnose approximately 90 per cent of diseases of the urinary tract Reports as to the reliability of the roentgen method of diagnosis by Sosman Rigler Garland and others agree substantially with these estimates and emphasize the high level of accuracy which roentgen study has attained

A correct roentgen diagnosis can be established only if the manifestations are clearly understood constantly borne in mind and painstakingly sought for in every instance In many instances the observer fails to utilize the roentgen study to its full value It is essential that every observation both positive and

possibilities Organic lesions may exist for considerable periods without producing symptoms and despite complete absence of clinical manifestations roentgen study may reveal the presence of pulmonary tuberculosis carcinoma of the lung and other serious lesions *It is a well known fact that one half* or more of all cases of significant pulmonary tuberculosis have no symptomatology or present manifestations which are so slight that they escape notice Carcinoma of the lung both primary and metastatic may be present for considerable periods before producing symptoms and most cases of bronchiogenic carcinoma are already inoperable at the time definite clinical diagnosis is established The National Tuberculosis Association estimates that there are probably 250 000 undiscovered cases of tuberculosis in the United States a number equal to the known cases Recent mass survey studies prove that the number of unknown cases of pulmonary tuberculosis far exceed the previous estimates Organic disease frequently presents atypical symptoms which lead to an incorrect diagnosis if sole reliance is placed on the clinical evidence It is not unusual for certain disease processes to mimic other lesions so closely that differentiation is difficult if not actually impossible *In many organic conditions the symptomatology* is obscure and the roentgen examination is essential to show the location type and extent of involvement There are many functional conditions with bizarre and atypical manifestions and these functional disturbances may closely simulate organic lesions Disease in remote parts of the body may be referred to the chest while pulmonary and cardiac lesions are not infrequently associated with manifestations in the abdomen pelvis and other regions of the body Thus a renal stone may cause symptoms which cannot be differentiated from those of appendicitis Gallbladder disease often closely imitates cardiac conditions In hiatus hernia there is in many instances a picture similar to that in coronary disease Cardiac anomalies can mimic many other conditions Radiculitis of the cervical and dorsal spine may closely simulate cardiac lesions Early pneumonia of the basal portions of the lungs particularly in children may be confused with appendicitis because of reference of the pain to the abdomen Conversely a retrocecal appendix may produce clinical mainfestations much like those which occur in pneumonia

It is important to bear in mind that there has been a marked change in the character of many diseases during recent years This is due particularly to the widespread use of the antibiotics With newer methods of therapy and the *tremendous advancements in cardiac* and thoracic surgery early and more accurate diagnosis and the prompt institution of the necessary therapeutic measures are now of the utmost importance Neoplasms of the lung can be diagnosed earlier and with more certainty by *roentgen examination than by other methods* Early pneumonia may similarly be shown on the roentgenogram before physical signs are present *particularly* in cases with a small deeply placed or central area of consolidation which cannot be detected on physical examination *Early* diagnosis in this type of case and the prompt institution of proper remedial *measures* is of lifesaving value Lung abscess and empyema may be modified and the course of the disease markedly shortened by the early establishment of the diagnosis and the prompt administration of antibiotics Many other examples in which the *roentgen* study is of aid in the diagnosis or the confirmation of the physical findings could be cited

It is possible to visualize approximately 90 per cent of pulmonary disease

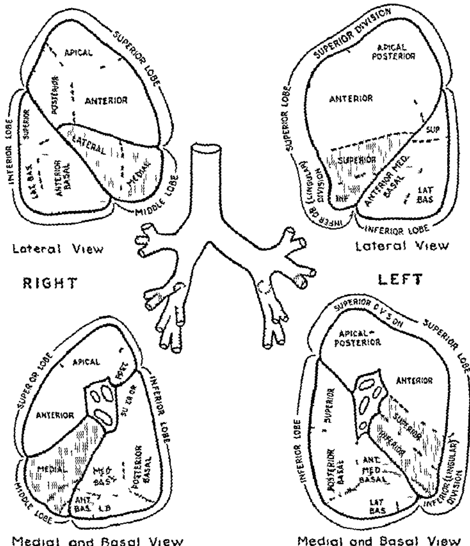
negative be made It is of equal value to understand the type of roentgen study necessary in the individual case and the special studies which will aid in arriving at the diagnosis The responsibility resting on those who undertake the interpretation of roentgen findings is great It is a very serious matter to label an individual as harboring tuberculosis carcinoma or other organic disease An erroneous diagnosis may result in great harm not only to the patient but also to the family Equally harmful may be the failure to establish a diagnosis in the early stages of a disease particularly if it is curable A patient with minimal tuberculosis or very early primary carcinoma of the lung may be cured by the prompt institution of the necessary remedial measures If however the roentgen changes are overlooked or not evaluated properly an interval of weeks or months may pass before the diagnosis is made By this time the disease usually has become moderately or far advanced and cure may no longer be possible

STUDY OF THE ROENTGENOGRAM AND THE INTERPRETATION OF THE FINDINGS

The thorax is an ideal region for roentgen study because of the sharply demarcated shadows produced on the roentgenogram by the varying organs and structures (Figs 1 and 2) The aerated lungs offer very little obstruction to the passage of the roentgen rays and hence produce radiant shadows Fatty tissues such as occur in the supraclavicular regions cause only slight absorption of the rays and are slightly more radiant than the air filled lungs The soft tissues of the thoracic wall the mediastinum the heart and great vessels and the diaphragms do not permit x radiation to pass through to as great an extent as the air filled lungs or fatty tissues hence are more dense on the roentgenogram As the body fluids have densities equal to those of the fleshy tissues the blood in the heart and vascular structures produces the same type of shadow as the soft tissue organs The bony structures are much less easily penetrated by the roentgen rays and in consequence are markedly more dense roentgenographically Metallic substances such as missiles and needle fragments and opaque media introduced for diagnostic or therapeutic purposes are more dense than the bony structures

It is essential that the radiologist develop a systematic and complete method of studying the roentgenogram and recording his findings The observations must not be made in haphazard fashion and once a workable system has been established it should be utilized consistently This results in completeness accuracy and the avoidance of errors of commission or omission The fluoroscopic observations are best incorporated into the final report Some observers prefer to record the fluoroscopic findings separately In our experience this leads to confusion and we are of the opinion that a single report combining all the features of the examination will prove most satisfactory The radiologist must train himself to observe every portion of the film carefully and minutely This will result in the avoidance of errors The entire thorax is viewed first to note the age sex habitus and any gross abnormalities (Figs 2 and 3) It is our custom to begin at the apices in the systematic study of the roentgenogram The apical portion of the lungs are observed individually and both sides compared The lung fields are divided into three zones (1) the peripheral portion includes the other third of the lung from the apex to the base (2) the middle zone and (3) the parahilar or central portion Each of these areas is studied for variations in density abnormal markings or other pathologic change The size position and contour of the hilus shadows are observed It is important to compare the two sides and it may be necessary to have the eyes travel back and forth from side to side several times before a final decision is made The linear markings of the chest must be studied carefully and it is essential that the normal appearances be kept clearly in mind The diaphragm is observed as to position contour and sharpness of detail The movements of the diaphragm are noted roentgenoscopically and should be recorded in every instance The costophrenic angles are studied

PLATE I



Dia rammatic repre ntation f the anatomical l ation of the egments f th l b of the lun (After J F Huber)

bronchi and blood vessels which vary in the manner of origin and communication with the hilus but are fairly constant in their distributions The right upper lobe is divided into four segments 1) anterosuperior 2) posterosuperior 3) anteroinferior and 4) lateral The right middle lobe is divided into 1) anteromedial and posterolateral segments The lower lobe has two subdivisions a dorsal and a basal The dorsal division requires no subnames The basal portion is divided into 1) posteromedial 2) posterolateral 3) anteromedial and 4) anterolateral The left upper lobe has two divisions a lingular and an apical The lingula is subdivided into anterolateral and posteromedial branches The apical portion of the left upper lobe is separated into segments in a manner analagous to the corresponding lobe on the right

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Mass Surveys Mass surveys of the chest have been used on large groups of individuals in the search for diseases of the lung and heart in industry by the armed forces prior to induction and many others At the Boston City Hospital as in many other large clinics every patient entering the hospital or out patient department is examined roentgenographically at the time of admission This is done by the photo fluorographic method the fluoroscopic image of the chest being photographed by a specially designed camera The film is usually of 70 mm size although in some instances a 35 mm or 4 × 5 film is used the small film being studied in a special viewer The mass surveys afford a general survey or screening method all doubtful or apparently positive cases being re examined with 14 × 17 inch stereoscopic roentgenograms and roentgenoscopy for final evaluation

The application of mass surveys to large unselected segments of the population has made it possible to determine the extent of undiscovered tuberculosis In a survey of 93 872 individuals Zacks found that in each 1 000 adult white persons 13 1 present evidences of tuberculosis with 5 2 active and 7 9 inactive Eighty per cent were classified as minimal 15 per cent moderately advanced and 5 per cent advanced An important point is that 98 per cent of the cases of advanced pulmonary tuberculosis discovered were entirely unsuspected before the roentgen studies of the chest were made

The value of mass radiographic studies is still the subject of considerable discussion Silverman states that the experience of the Baltimore City Health Department with the application of mass radiography to about 5 per cent of the population comprising 48 175 apparently healthy individuals resulted in only a modest yield of cases of tuberculosis in relation to the effort expended The results as concerns the discovery of the disease in the early or minimal stages were disappointing Of 1 468 cases of pulmonary tuberculosis which were brought to the attention of the officials during the year 202 were of the minimal active variety and in this group only approximately one fourth were found in the survey The proportion of new cases with the disease in minimal active stage was not greatly increased despite the tremendous amount of effort required for the mass survey Attempts to determine which particular segments of the population were contributing in greatest measure to the problem of tuberculosis were not successful The incidence of positive cases was quite similar in the various adult groups studied except that the school groups composed mainly of adolescents showed a lower rate Final evaluation of the merits of mass surveys must await further study and the accumulation of more data on large series of cases in different parts of the country

Mass survey studies by photofluorographic methods are particularly valuable in the study of large segments of the population While the surveys are utilized principally to uncover cases of tuberculosis the method has also proven its value in many other ways Asymptomatic and unsuspected cases of neoplasm of the lung mediastinal tumors and anomalies of the heart great vessels and bony thorax are discovered in a small but appreciable and important number of cases The exclusion of the presence of disease of the lungs and heart in the negative cases is of the utmost importance to the clinician and the patient The mass survey photoroentgenogram supplies an invaluable record of the condition of the patient which may be of inestimable aid for comparative purposes at a later date It has been our practice for many years to include a chest roentgenogram in all patients referred for examination of the gastrointestinal tract This procedure might well be extended to every extensive roentgen study All cases admitted to the hospital should have roentgen examination of the chest performed routinely at the time of admittance In every major surgical procedure a record of the chest findings as obtained by use of the x ray is essential Patients with malignant neoplasm require frequent roentgen examination of the chest and other areas in the search for metastatic foci

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THE NORMAL CHEST

The appearance of the normal chest must be clearly understood before any attempt is made to determine the existence of abnormalities or disease processes. There is no one single picture which is characteristically or entirely normal, the roentgen findings varying with the age, sex and habitus (Figs 5 and 6) of the patient as well as exposure to dust, previous infections and many other factors. However, the observer must learn by the study of large numbers of roentgenograms to determine what may be considered within normal limits, just as the student acquires by practice a conception of what comprises the normal breath sound on stethoscopic examination (Figs 1–9).

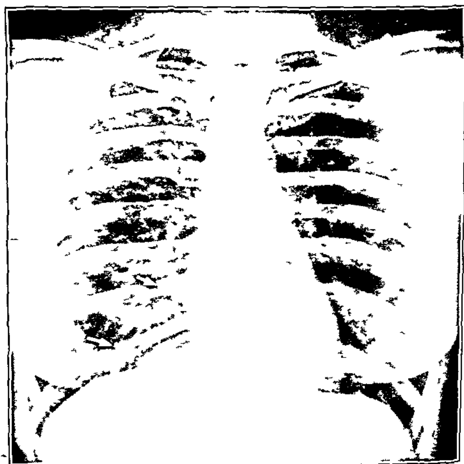


Fig 9.—Right Inferior Accessory Lobe

There is an area of irregular mottled density in the paravertebral portion of the right lower lung field. A linear band of increased density extending from the inferior portion of the hilum downward and laterally to the mid portion of the right diaphragm demarcates the lateral margin of the inferior accessory lobe (white arrows).

The air filled lungs are visualized as areas of radiance extending from either side of the shadow of the spine heart and great vessels to the peripheral portion of the chest For purposes of description the lung fields are usually divided into 1) a central 2) a middle and 3) a peripheral zone 1) In the central portion there are small poorly defined irregular areas of increased density called the hila or root shadows These are made up of the pulmonary blood vessels the bronchi and a group of lymph nodes The left hilum is partially obscured by the overlying shadow of the heart and great vessels and lies at a slightly higher



FIG 10 —Lateral Roentgenogram of the Chest to Demonstrate the Location of the Lobes of the Right Lung

UL upper lobe ML middle lobe LL lower lobe

The upper lobe occupies the anterior and upper portions of the chest The middle lobe overlies the heart and lies anteriorly in the lower third of the lung field The lower lobe occupies the middle and lower portions of the posterior aspects of the chest The septum between the right upper and middle lobes is shown at the white arrow The long septum between the upper middle and lower lobes is indicated at the black arrows

level than the right 2) In the middle third of the lung there is a series of linear shadows which are wider and denser in the region of the hila and decrease progressively toward the periphery These are termed the linear markings of the lungs and are formed by the bronchi arteries veins and lymphatics They are most marked in the paracardiac portion of the right lower lung field and the paravertebral portions of the upper lungs Bronchi seen on end form ring like areas of increased density while blood vessels similarly visualized present a round dense homogenous shadow 3) In the peripheral zone of the lungs only few or no

lung markings are normally present The apices of the lungs comprise the portions which lie above the clavicles and the anterior aspect of the first ribs Normally the left apex is slightly more radiant and rises to a higher level than the right due to the fact that it is somewhat larger the ratio of the volume of the left apex to the right being as 11 is to 10 The diaphragms are visualized as rounded smooth sharply defined shadows the right normally being one interspace higher than the left The right leaf of the diaphragm merges with the shadow of the liver and is normally not visualized except along its superior surface On the left the presence of gas in the stomach and splenic flexure may enable the observer to delineate the superior and inferior surfaces of the diaphragm The costophrenic sinuses are moderately deep and approximately equal in size on



FIG 11 —The Interlobar Septum on the Left Side

The interlobar septum is thickened throughout its entire extent (black arrows) The left upper lobe lies in the upper and anterior portions of the chest The left lower lobe occupies the posterior and inferior portions of the chest Normally *the interlobar septum* is straight In the case illustrated there is slight upward bowing due to atelectasis of the upper lobe and compensatory emphysema of the lower lobe

the two sides The central density extending vertically between the two lung fields is made up of the shadows of the dorsal spine heart great vessels and mediastinal structures The mediastinum is visualized in oblique and lateral projections Fluoroscopic observations are of the utmost importance in the study of the excursions of the diaphragms and the mediastinal structures The pleura is normally not visualized although pleural reflections between the lobes may in certain projections result in linear bands of density The mediastinal pleura may similarly cast a linear shadow in the paravertebral regions on each side

The lobes of the lungs are normally not distinguishable one from the other However it is of the utmost importance to have clearly in mind the anatomical locations of each of the lobes (See Plate 1 p 34) It must be stressed that the divisions between the lobes do not lie horizontally in the chest but rather obliquely (Figs 4 10 11) The fissure between the right upper and lower lobes extends from the third dorsal vertebra posteriorly to the diaphragm about 2 to 3 cm from its anterior aspect The minor septum on the right extends from the major fissure at the level of the fourth rib in the axilla to the hilum at about the second rib anteriorly On the left the division between the upper and lower lobes extends from the fourth dorsal vertebra downward and anteriorly to the diaphragm The upper lobes lie mainly anteriorly while the lower lobes occupy the postero inferior aspects of the chest The right middle lobe is in the inferior portion of the anteromedial aspect of the chest It must be borne in mind that the lobes overlap each other to a considerable extent and in the sagittal roentgenograms no clear idea of the localization of each lobe is possible If it is desired to determine which lobe or lobes are involved in a pneumonic process or to localize an encapsulated effusion lung abscess or tumor oblique and lateral projections must be utilized in addition to the sagittal studies the lateral positions being a prime essential in the accurate delineation of the various lobes of the lung Visualization of the bronchi and trachea requires bronchography with iodized oil Similarly the injection of 70 per cent diodrast into the veins of the arm permits of outlining the shadows of the blood vessels in the pulmonary areas The ribs clavicles scapulae and portions of the humeri are clearly outlined on the roentgenograms and anomalies of these structures should be carefully sought for as important aids in diagnosis

THE PNEUMONIAS

Lobar Pneumonia – In lobar pneumonia roentgen study has proven one of the most important aids at the disposal of the clinician and is indispensable in arriving at a diagnosis following the course of the disease and determining the development of complications The presence of a pneumonic process may be established earlier and more accurately by roentgenography than by clinical methods The roentgen changes are demonstrable within a few hours after the onset of the process The extent and location of the disease process can be shown with accuracy *The formation of fluid* abscess *or other complication* is best determined by roentgen study The early administration of antibiotics may mask or obscure the clinical manifestations and roentgenography is particularly important after the administration of penicillin streptomycin and similar drugs to assist in establishing the diagnosis In children with unexplained abdominal complaints roentgenograms of the chest are essential as a pneumonic process may simulate appendicitis and other subphrenic or intraabdominal conditions Similarly acute abdominal processes in children may present symptoms referable to the chest and roentgen study of the lungs is essential to exclude the presence of pulmonary disease In the aged and in patients too ill for a satisfactory and complete clinical examination roentgen study affords a simple and dependable *method of showing areas of pneumonia which may not be demonstrable by* the usual methods of physical examination This is particularly true of areas of consolidation in the retrocardiac area or small patches of central pneumonia During infancy and childhood pneumonia may be present for even one or two days without producing definite physical signs Roentgen examination in the early stages of the disease in this type of case affords a means of demonstrating the presence *and location of the disease*

The roentgen examination should include both roentgenograms and roentgenoscopic study although in the patients too ill to be brought to the *x* ray department examination with the mobile machine at the patient s bedside usually suffices Lateral projections are of the utmost importance to determine the lobe or lobes involved as the antero posterior and postero anterior roentgenograms do not permit the observer to state with exactness which lobe is affected (Fig 18) Roentgenoscopy is of great value in the early stages of the disease and also in the *determination of the completion of resolution at the end of the disease* In the first hours after the onset of lobar pneumonia the sole manifestation may be elevation and limitation of the diaphragm on the affected side particularly in processes involving the lower lobes If roentgenoscopy cannot *be performed* films after inspiration and at the end of expiration may afford valuable data as to the presence or absence of mobility or limitation of excursions of the diaphragm In patients who are extremely ill and uncooperative it may not be *possible to* make roentgenograms after inspiration and expiration Valuable data may be obtained by noting the degree of sharpness and the relative position of the two leaves of the diaphragm In patients who are breathing very rapidly *the dia*

phragm on the unaffected side is apt to be slightly hazy or blurred due to respiratory motion However the diaphragm on the involved side appears very sharply and clearly outlined due to the pleurisy which results in marked limitation of motion or fixation We have been able to predict that an area of consolidation would appear at the base of the lung in a matter of hours or one or two days by the demonstration of this change in the diaphragm thus establishing the diagnosis before actual consolidation had developed

Roentgen Manifestations (Figs 12 to 18) —The roentgen manifestations of lobar pneumonia vary with the stage and extent of the disease In the first few hours after the onset there may be only slight haziness in the involved area elevation limitation or fixation of the diaphragm and narrowing of the inter spaces on the affected side Roentgenoscopy is extremely important at this stage of the process Careful comparison of the affected area with the uninvolved segments of the lung is essential to show these early changes This is termed the congestion stage After the lapse of 3 or more hours the consolidation becomes evident on the roentgenogram (Fig 12) The area of consolidation may be central or peripheral in location The shape is triangular rounded or oblong The margins of the involved area are irregular and poorly defined A lesion of the upper lobe does not affect the diaphragm (Figs 13 and 14) Pneu monia in the middle lobe or the lower lobes is associated with elevation limitation of motion or fixation of the diaphragm on the involved side (Fig 18) After an interval of a few days the consolidation increases and the consolidated lobe or lobes become increasingly dense The stage of actual consolidation is termed red hepatization At this stage the process may vary in degree from a slight diffuse mottling to an extensive area of uniform increased density limited to the lobe or lobes involved The outline of the ribs heart border and diaphragm are usually visible through the area of diminished radiance although in many instances these structures may be obscured or obliterated At the margin of the affected lobe the density is sharply delineated Elsewhere the borders of the area of consolidation may be clearly defined or hazy and irregular In disease of the upper lobes the apices of the lungs are usually not affected and may be of normal radi ance or show only very slightly diminished radiance Lateral views are essential to identify the lobe or lobes affected Lesions in the retrocardiac region cause the heart shadow to appear denser than normal in the sagittal projection In volvement of the lower lobes is accompanied by elevation and fixation of the diaphragm The density in the affected portion of the lung is usually marked and tends to be uniform in character because of the presence of exudation fluid fibrin and blood in the alveoli

The affected lobe or lobes may be larger than normal in which case the trachea and heart shadow are displaced to the opposite side and the interspaces are wid ened If patches of atelectasis develop due to a blocking of the bronchioles by mu cous and exudate the diseased portion of the lung is decreased in volume with narrowing of the interspaces and deviation of the heart and trachea toward the affected side In most instances of pneumonia the consolidated portion of the lung remains normal in size It is obvious therefore that there is no definite rule as to the size of the involved lobe or lobes in cases of lobar pneumonia The area affected may be of normal size increased in size in the presence of fluid in the alveoli or decreased in size if atelectasis supervenes

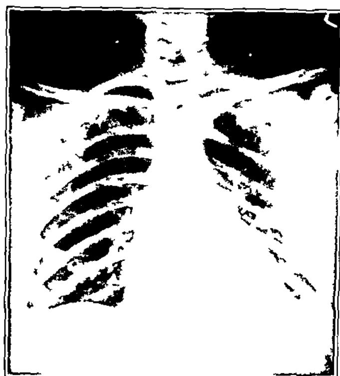


Fig 12 —Early Lobar Pneumonia Left Lower Lobe

There is an area of irregular mottled density involving the lower third of the left lung field with elevation and flattening of the left diaphragm The left costophrenic angle is shallow *There is narrowing of the left lower interspaces*



Fig 13 —Lobar Pneumonia Right Upper Lobe

A Sagittal roentgenogram There is markedly increased density involving the right upper lobe The inferior margin of the area of density is delimited by the interlobar septum The right upper ribs are obscured The heart and trachea are not displaced

B Lateral roentgenogram The pneumonic process is limited to the right upper lobe The right lower and middle lobes are moderately emphysematous

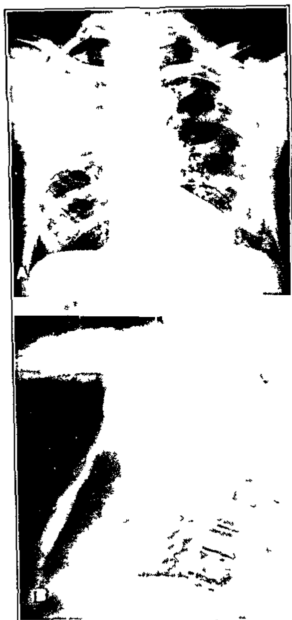


Fig 14 —Lobar Pneumonia Right Upper Lobe

A Sagittal roentgenogram There is an area of irregular mottled density occupying the upper half of the right lung field The density extends from the level of the clavicle to the interlobar fissure The inferior margin of the density is smooth and sharply defined The apex of the right lung is not involved a frequent occurrence in lobar pneumonia of the upper lobe

B Lateral projection The area of consolidation lies in the posterior aspect of the right upper lung field in the region of the upper lobe and is sharply delimited by the interlobar fissure

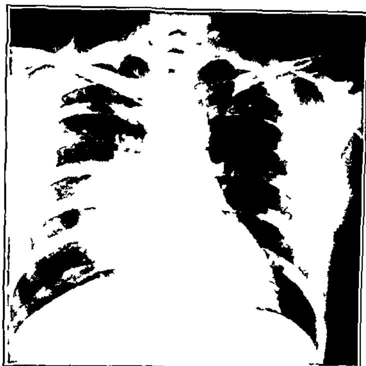


Fig 15 — Central Pneumonia Right Side

The pneumonia is evidenced by an area of irregular mottled density in the paracardiac region The density does not obliterate the outlines of the ribs or heart border The right diaphragm is elevated



Fig 16 — Lobar Pneumonia

A There is diminished radiance and diffuse mottling throughout practically the entire right lung field and the lower half of the left lung field bilateral lobar pneumonia

B Two weeks later The pneumonic process has undergone almost complete resolution

Resolution is manifested by increase in radiability and diffuse mottling these hanges progressing as the clearing increases The resolution may begin at the eriphery centrally or in irregularly scattered patches During this stage there frequently increased density at the peripheral portion of the lungs and in the egion of the interlobar septa This is explained by the accumulation of fibrinous

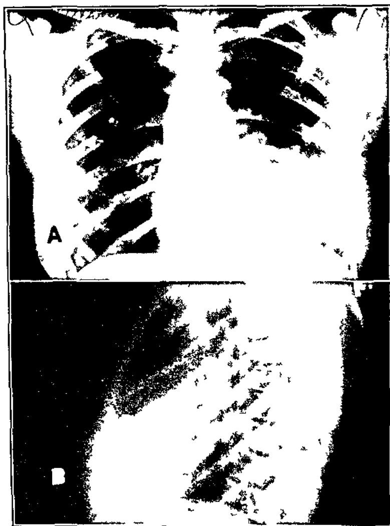


Fig 17—Lobar Pneumonia Left Side in the Lingular Portion

A Sagittal projection There is an extensive area of mottled density involving the lower third of the left lung field The density presents the characteristic appearance of a lobar pneumonia with obscuration of the lower ribs and heart border The left diaphragm is elevated and flattened and the left costophrenic angle is shallow The left lower inter spaces are slightly narrowed In this projection the pneumonic process appears to be in the lower lobe

B Left lateral projection The pneumonic process involves the anterior and inferior aspect of the left lung The involvement is in the lingula which corresponds to the middle lobe on the right side



FIG 18 —Pneumonia Right Middle Lobe

A Sagittal projection There is an area of consolidation in the middle and lower portions of the right lung field The superior margin of the area of density is horizontal and sharply defined lying at the level of the interlobar fissure The right diaphragm is elevated and sharply outlined From this projection alone it is not possible to state whether the consolidation involves the lower lobe the middle lobe or both

B Right lateral projection The consolidation occupies the anterior aspect of the right lower lung field in the region of the right middle lobe The lower lobe is not affected Lateral projections are essential to determine the lobe or lobes involved and should be used routinely

exudate at the pleural surfaces. The rate of resolution varies widely and may be affected markedly by the use of the antibiotic drugs. Delayed resolution or unresolved pneumonia is uncommon but does occur in a small percentage of cases. Patches of irregular mottled density which vary widely in size and distribution may persist for many weeks. The progress of the clearing is best followed by roentgenograms taken at intervals of a few days or a week. Roentgenoscopy and lateral projections are essential in addition to the usual antero posterior and postero anterior roentgenograms to determine the progress of the resolution particularly to delineate small areas in the retrocardiac region and at the extreme bases. Pleural effusions are common during the course of a pneumonic process. The fluid may accumulate at the bases, the interlobar septa, or the mediastinal surfaces. Encapsulated fluid is common. Small areas of encapsulation often are demonstrable only by oblique or lateral projections and roentgenoscopy in various positions. Lung abscess may develop as a sequel to pneumonia and presents the characteristic manifestations which will be described in detail subsequently.

In lobar pneumonia of the bacterial type the diagnosis may be definitely established very early in the disease by the use of the roentgen examination. Within 2 or 3 hours after the sudden onset of the symptoms of a typical lobar pneumonia definite roentgen changes are apparent. By the end of 6 to 12 hours the roentgen manifestations are usually well developed and sufficiently marked to permit of a definite diagnosis, although the physical examination at this time may give indications which are at best indefinite or indistinct. Thus a normal roentgenogram twelve or more hours after the development of clinical manifestations indicative of the presence of a bacterial type of pneumonia may be accepted as definite evidence that the disease is not present.

Bronchopneumonia.—Bronchopneumonia differs in many important respects from the lobar types of pneumonia and an understanding of these differences is essential for a proper comprehension of the variations in the clinical and roentgen findings in the two diseases. Bronchopneumonia is an inflammation of the smaller bronchioles and the terminal air vesicles. A part or all of the lobule may be involved. In most instances both lungs are affected, the process usually being most marked at the bases. Approximately two thirds of the cases of bronchopneumonia are caused by some type of pneumococcus. The remainder are due to the streptococcus and other pathogenic bacteria. Bronchopneumonia is usually secondary to bronchitis and frequently follows an upper respiratory infection. The primary feature of lobar pneumonia is an exudative inflammation which eventually resolves and clears completely. Bronchopneumonia, on the contrary, is a productive inflammation which is characterized by infiltration of the walls of the bronchi and bronchioles with mononuclear cells. As the disease progresses these cells produce a dense encirclement of the bronchi with compression and varying degrees of obstruction of the lumens. The mucosa of the bronchi shows extensive inflammation and the lumens are filled with purulent secretions. The air spaces around the involved bronchi may collapse and become distorted due to pressure. However, there is no exudation into the alveoli. Therefore in bronchopneumonia the bronchi are compressed and plugged with large amounts of purulent exudate which may produce localized atelectasis and emphysema. It is these latter manifestations which are responsible for the clinical signs of the disease.

In many instances bronchopneumonia is characterized by a gradual and insidious onset the disease usually originating in the lungs as an extension from upper respiratory infections This is in sharp contrast to lobar pneumonia which has a sudden and dramatic onset The temperature rises but never becomes markedly elevated and tends to be irregular There is severe cough and the secretions from the bronchi and upper portions of the respiratory tract are thick purulent and may contain blood The physical findings are few in number and variable There is usually no dullness on percussion Diffuse rales may be scattered throughout the upper chest or more commonly are localized at the bases The roentgen manifestations vary markedly in different cases There is frequently only a generalized accentuation of the markings in the region of the hilum and the periphery The hilus shadows are usually enlarged and irregular The roentgenograms may show patchy irregular areas of increased density scattered throughout the lung fields These frequently change markedly on subsequent examinations due to the fact that the densities in the lungs are due to consolidation and associated areas of atelectasis Large conglomerate areas of increased density occur in some instances and are either unilateral or more commonly bilateral The diagnosis of bronchopneumonia must be established on the basis of the clinical course and the toxemia The absence or paucity of localized physical signs in the chest is in pronounced contrast to the striking manifestations in the typical case of lobar pneumonia Similarly the roentgen findings in bronchopneumonia are much less marked than the clinical manifestations would lead one to expect Many instances of well developed and advanced bronchopneumonia in which the clinician can establish the diagnosis with certainty by the history and physical examinations may show no roentgen changes It is very difficult for the radiologist to render a report of practically normal conditions when clinically there is unquestionable disease in the lungs This must be recognized and the diagnosis established by the clinician without waiting for the roentgen examination to become positive

Roentgen Manifestations (Fig 19–21) —The clinical manifestations of bronchopneumonia are frequently indefinite and atypical particularly in children and the aged the two groups which are especially apt to be affected by the disease Similarly the roentgen manifestations vary widely in different patients and in the same patient at different stages of the disease In some instances very small or deeply seated areas of bronchopneumonia are not demonstrable on the roentgenogram Characteristically there are patches of irregular mottled density which are usually limited to the lower third of the lung field and bilateral in distribution The size of the areas of density in the lung fields varies widely In some cases the patches are small and discrete while in others they are very large and occupy the greater portion of one or more lobes In the typical case the disease is not limited by the lobar boundaries as in lobar pneumonia the patches of density being irregularly scattered throughout one or more lobes (Figs 20 21) Involvement of the upper lobes and in the region about the hila is less common but does occur occasionally The margins of the involved areas are irregular hazy and taper off gradually into the adjacent lung tissue The unaffected portions of the lungs are of normal radiance or show slight degrees of *compensatory emphysema evidenced by increased radiance and prominence of* the linear markings The diaphragms are normal in outline position and respiratory excursions The costophrenic angles and the posterior mediastinum remain

Section III

THE DIAPHRAGM

Section IV

THE PLEURA

Section V

THE BONY THORAX AND THE SOFT TISSUES OF THE CHEST WALL

as to depth clarity and position Careful observation is made of the heart and great vessels and should include the position contour and size of each of the chambers and the supracardiac area The mediastinum is examined in the anteroposterior oblique and lateral roentgenograms for abnormalities in size density or position It is essential to note the position of the trachea in every instance as deviation or changes in size are important The major bronchi can also usually be visualized and variations in these structures are of diagnostic significance The lateral projection (Fig 4) is of extreme importance in cases of emphysema the localization of masses or tumors abscesses in the lungs and the study of the posterior mediastinum The retrosternal and retrocardiac areas should be observed as to size and degree of radiability The position of the diaphragm heart and trachea in the lateral projection are of the utmost importance and the densities and relations of the structures must be carefully studied

The visualized ribs and the other bony structures of the thorax must be observed carefully and in minute detail This is frequently not done in consequence of which destructive changes involving the bony thorax are not discovered Paget s disease osteoblastic metastases and other conditions may involve the clavicles ribs humerus or scapula and a diagnosis which otherwise would not be made can be established with definiteness from the roentgenogram of the chest It is our custom in dictating the report of the chest to always terminate by stating the visualized ribs are not remarkable or if there is a lesion in the bony thorax making the necessary description and conclusion In this way it becomes necessary to study the ribs in every instance and once the habit is established it is then carried on automatically By thus studying each portion of the roentgenogram carefully and in detail no deviation will be overlooked and a thorough study of the chest and its contents will result

It is essential that the quality of the roentgenograms be as nearly perfect as possible before interpretation is undertaken If the film is too light because of too little exposure or under penetration the linear markings appear prominent and the hilus shadows are larger giving a false impression as to the existence or absence of a pathologic process A roentgenogram which is too black because of excessive exposure and or overpenetration may fail to reveal important details and early or small pathologic processes can be overlooked The roentgenologist must insist on as nearly perfect roentgenograms as possible in every instance before the examination is completed If the roentgenogram is unsatisfactory or additional studies are indicated re examination should be carried out

The principal duty of the roentgenologist is to interpret the findings as demonstrated on the roentgenogram Two steps are necessary The first consists of careful complete and accurate observation of the films in order to elicit every fact of importance In no instance can fluoroscopy alone be depended upon for a complete study The roentgenograms should be studied methodically Speed is not an essential The obvious anomalies which are quickly recognized at first glance must not mislead the observer and prevent the recognition of small or hidden details which may be of equal or greater significance in diagnosis Errors of omission are as serious as errors of commission It is equally important not to read too much into the film as not to overlook any detail however slight It is essential to observe and record every fact negative or positive which may be of value in arriving at a conclusion The roentgenologist must then interpret the findings in terms of pathology and pathologic physiology Here also it is of as great importance to avoid making an incorrect diagnosis as it is to arrive

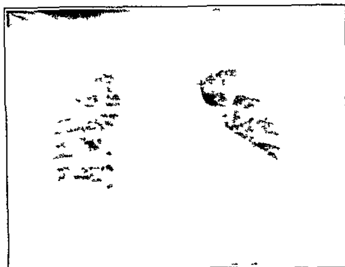


Fig 5 —Normal Chest in a Hypersthenic Individual

The di phragm are elevated and the chest appear br ad and short The heart l es transversely and tends to app ar l rge without actually being increa ed in size The lungs are less radi nt than in th asthenic or pt ti type of indivdu l



Fig 6 —Normal Chest Asthenic Type

In persons of the a tl enic or ptotic hab tus the diaphragms are depressed the heart shadow assumes horiz ntal p it n and the chest is l ng and narrow The lung fields are radiant and the br n hova ular markings are clearly visualized

at the correct conclusion Irreparable harm may come from an erroneous diagnosis of tuberculosis or syphilis when the disease is not present While it is important to attempt to make a diagnosis as early and as accurately as possible it is wrong for the roentgenologist to make a presumptive diagnosis of carcinoma tuberculosis or other serious conditions when the disease is not present or the evidence is inconclusive The radiologist is a consultant and should avail himself of every clinical fact which may assist him in arriving at a correct conclusion While many lesions may be definitely diagnosed from the roentgen examination alone it must be borne in mind that the roentgen findings indicate gross changes which cannot always be translated into microscopic findings An area of tuberculosis may very closely simulate early neoplasm formation An abscess full of fluid may easily be mistaken for a tumor Primary and metastatic neoplasms often produce essentially similar findings Lesions such as bronchitis and bronchiectasis may give little or no roentgen evidence of their presence even though the disease is established clinically On the other hand tuberculosis deep seated neoplasms and many other disease processes can be demonstrated by roentgen methods long before they give clinical evidence of their existence A proper evaluation of these facts is essential and must be borne in mind at all times by the radiologist and clinician

In many instances the radiologist can supply more important and more accurate data than is obtainable by any other method This is particularly true in the study of the lungs A development similar to that in the field of clinical laboratory medicine is now evident in the field of radiology It is obvious that within the next decade roentgen study of the chest will become as commonplace as the examination of the blood and urine in the laboratory today With this ever widening field of usefulness of radiology particularly in the field of diseases of the chest there may come a lowering of the standards This should be guarded against by thorough methods and techniques careful evaluation and proper technical methods with an insistence on the highest standards of excellence in every aspect of the examination and interpretation Roentgenologists and clinicians are generally aware that a single roentgenogram either of the standard size or miniature variety obtained by photofluorography does not comprise a complete roentgen study There is also an awareness that an incomplete study may result in irreparable harm as failure to demonstrate a small focus of tuberculosis or an early neoplasm of the lung may result in a false sense of security and permit of advancement of the disease process before the diagnosis is finally established No roentgen study of the gastrointestinal tract is considered complete without complete roentgenoscopy numerous spot films exposed during fluoroscopy both with and without compression and routine roentgenograms in various projections and with varying degrees of filling of the viscus under observation

The tendency on the part of many observers to render a negative report on the basis of a single roentgenogram of the chest is greatly to be deplored A complete roentgen study of the chest is essential in every case and should be carried out with as much care and thoroughness as other clinical examinations The early and accurate diagnosis of pulmonary tuberculosis neoplasm of the lung mediastinal tumor cardiac disease and many other lesions which may best be demonstrated by roentgen methods has proven of inestimable value The dependability of roentgen study is proportionate to the care and completeness of the examination In skilled and competent hands it is a highly accurate method of study

Section I

ROENTGEN METHODS OF EXAMINATION OF THE LUNGS

Roentgenography —During recent years roentgen study of the chest has assumed a position of prime importance in clinical medicine and at the present time many clinicians do not consider the examination of the chest complete without the data afforded by roentgenography and roentgenoscopy In most clinics the roentgenographic findings are an integral part of the routine study of the individual case much as the physical examination the blood studies or the urinalysis This is due to several reasons the most important of which is that by roentgenography it is possible to demonstrate small or deeply seated lesions which may give no evidence of their presence by the more commonly used methods of examination such as percussion palpation and auscultation This is particularly true of early tuberculosis small or central areas of consolidation in pneumonia bronchiectasis and primary or metastatic neoplasms of the lung In previous years there was considerable controversy often prolonged and heated between the clinician and radiologist as to the relative merits of the physical examination and the roentgen examination It is now universally recognized that the two methods are not antagonistic rather are complementary to each other and that a proper combination of both will prove of optimum benefit to the patient and examiner

Every roentgenogram of the chest must be of perfect detail with the sharpest possible definition and clarity of outline Any roentgen study in which the films are blurred because of motion or lack of definition should not be utilized and the patient reexamined The reasons for this are obvious Small lesions may be blotted out or so indistinctly outlined that their significance is not appreciated Slight changes which permit of a diagnosis of early disease may not be visualized unless the film is perfect in every respect The projections utilized in the roentgen examination of the chest vary with the type of case under consideration In routine surveys of large segments of the population a single posteroanterior roentgenogram affords much important data However if this view alone is relied on many processes which otherwise may be demonstrable will be overlooked because of the size location or relative density of the lesion A posteroanterior and right lateral roentgenogram are utilized routinely at the Boston City Hospital These are supplemented by anteroposterior left lateral and oblique views if an indication for these additional studies is noted during fluoroscopy The roentgenograms are made with the patient standing if possible Stereoscopic roentgenograms have many advantages and should be made whenever possible The chest must be pressed firmly against the cassette holder The patient is instructed to take a deep inspiration hold the breath in this phase of respiration and remain absolutely motionless during the exposure A fine focus rotating

anode tube is utilized. The target film distance should be 5 to 7 feet to reduce distortion and magnification. Intensifying screens should be clean and of the par speed or high speed variety. The roentgen exposure time should be 1/10th second or less to insure complete immobilization of the patient and in order to minimize motion of the heart and other vascular structures. The thickness of the chest is measured in each instance and the kilovoltage or exposure time varied according to the size of the patient. For the lateral exposure the patient places the arms above the head and holds the breath at the end of a full inspiration. The kilovoltage or time are increased. If fluid levels are to be demonstrated lateral decubitus roentgenograms are also made. The planigraph is utilized to localize masses, abscesses or tuberculous cavities.

If the patient is too ill to stand and has come to the *x* ray department on a litter the roentgenograms must be taken lying or sitting. Films with the patient lying are not always satisfactory. However they have a definite place in the demonstration of large areas of consolidation, tumors, accumulations of fluid and other abnormalities. The distance from the roentgen film to the target of the tube should be as great as possible. Distances of less than 30 inches are seldom satisfactory. We use a target film distance of 5 feet and preferably 6 feet whenever possible. This is accomplished with the floor ceiling tube stand which has many advantages over the conventional type of tube stand. If the patient can sit on the litter or a chair the roentgen film is placed in position and held by a special retaining bracket or by an attendant while the exposures are made. Anteroposterior, posteroanterior and lateral views should be utilized if possible in every instance.

Patients too ill to come or be transported to the roentgen department must be examined with the portable machine at the bedside. The average portable roentgen machine delivers only 10 to 30 milliamperes and consequently a much longer exposure time is required. Anteroposterior views are the rule in this type of study and often must be made in the supine position. It is seldom possible to obtain perfect lateral views except in cooperative and thin individuals. However the lateral view should be obtained as well as the anteroposterior and posteroanterior if possible. Roentgenograms in the sitting position or the lateral decubitus may show fluid levels which would not be demonstrable if the study is made with the patient recumbent, especially in hydropneumothorax, cysts and abscess of the lung. An important diagnostic procedure and one which is particularly useful in the case of the occasional patient who cannot be fluoroscoped is the making of roentgenograms at the end of inspiration and expiration. This permits of observation of the diaphragmatic excursions. It also aids in the demonstration of small areas of pneumothorax, mediastinal shifts and arteriovenous aneurysms of the lung. A valuable yet simple procedure is the making of an overexposed roentgenogram with the aid of the Bucky diaphragm. This is particularly important to show areas of bronchiectatic dilatation, small patches of consolidation or tumors behind the heart and may also serve to differentiate between fluid, atelectasis and consolidation. Lesions of the ribs, spine, shoulder girdle and sternum may be shown and a diagnosis of metastatic carcinoma, osteomyelitis or tuberculosis of the rib solves a difficult problem if this maneuver is utilized. The posterior lordotic position (Fig [illegible]) is of great value in the study of the apices of the lung and may show small or early lesions which cannot be visualized in the routine projections. In the roentgenograms of the chest

with usual techniques the apices and upper lung fields are frequently obscured by the shadows of the clavicles and overlying ribs The lordotic position is especially valuable in the demonstration of the lesions of early tuberculosis and neoplasms in the apical and infraclavicular regions

It is the duty of the roentgenologist to supervise the processing of the roentgenogram The film should be developed at the proper temperature rinsed fixed and washed before being hung to dry Care must be taken during the drying to ensure that the film is not scratched or marred by the deposition of dust or dirt which may obliterate important details The roentgenogram must be identified by a lead marker or other suitable device before it has been processed Assigning

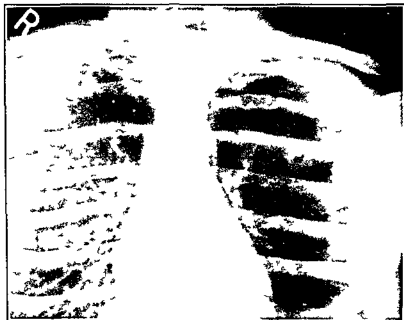


Fig 7 —Normal Chest with the Patient in the Lordotic Position

With the usual techniques the apices are frequently obscured by the clavicles and the upper ribs In the lordotic position early changes in the apex and infraclavicular area are clearly demonstrated

the wrong film to a patient may result in serious errors In survey examinations or larger clinics this is a vital factor and the proper identification and filing of the films is a matter of the utmost importance

Roentgenoscopy —Fluoroscopy comprises a most important part of the roentgen study and should be performed in every case by a competent roentgenologist The clinician may use roentgenoscopy as a general survey method and many physicians now properly do so However early or small lesions are often not demonstrable by fluoroscopy alone Thus a false sense of security may result if dependence is placed on this method of study by those who are untrained or do not also make use of complete roentgenographic studies in conjunction with the fluoroscopy Roentgenoscopy must be carried out systematically and in considerable detail The pupils should be well dilated before the examination

is begun Complete adaptation requires at least 20 minutes in a darkened room Many observers neglect this and in consequence do not obtain the full benefit of the roentgenoscopy Fluoroscopy is carried out in the anteroposterior postero anterior lateral and various oblique projections Each lung field is studied minutely and in detail with both large and small apertures The motions of the diaphragm are observed The cardiac contours and movements are studied The mediastinum must be viewed in several projections The patient is examined in both inspiration and expiration and after coughing This is particularly important as regards the apices of the lungs and the diaphragmatic excursions A barium swallow is an important adjunct to demonstrate enlargement of the left auricle displacement of the esophagus by a mediastinal mass or lesions of the esophagus such as cardiospasm malignancy or congenital shortening The fluoroscopic observations should be carried out in every patient first in order to determine the type and number of roentgenograms required although in many large clinics or during mass surveys roentgenoscopy is not done routinely being reserved for special cases On completion of the fluoroscopic observations the technician is instructed as to the number and type of roentgenograms to be taken

Body Section Radiography —Body section radiography is defined as a type of roentgen examination in which a predetermined layer of the body is studied to the exclusion of other areas above and below the section under observation This is accomplished by having the x ray tube and film move in opposite directions about a fixed axis during the exposure time used in making the roentgenogram This procedure has been termed laminography planigraphy roentgen section sectional radiography tomography and many other designations The description of the apparatus is complicated and is not essential in a discussion of this type It is necessary for the observer to determine the depth at which the study is to be made If this is not possible serial roentgenograms are made at varying depths usually at distances of 1 cm apart In this way it is possible to examine one portion of the skull the chest or other regions of the body without the superimposition of other confusing shadows The method has the widest application in the study of the tumor of the lungs and mediastinum cavities patches of atelectasis *and occlusions of the bronchi It is possible to visualize divisions of the* bronchial branches as small as 3 to 4 mm in diameter and very small cavitations can be outlined Distortion termination or occlusion of the bronchi is demonstrable Mediastinal tumors or growths in the lung near the midline may have their true location and point of origin proven Non opaque endobronchial foreign bodies are revealed whereas they cannot be visualized on routine roentgenograms The larynx and paranasal sinuses afford a favorable field for study by this method In the vertebræ particularly in the cervical region overlying shadows such as the base of the skull and mandibles cause great difficulty in diagnosis The first and second cervical vertebræ are particularly amenable to observation by this method and fractures of the axis and atlas which otherwise might not be shown can be clearly brought into view The axial skeleton can usually be studied satisfactorily by anteroposterior and lateral projection Lesions of the sacrum and hip are very difficult to visualize by ordinary method but *are clearly shown by laminography The base of the skull* the temporo mandibular joints the mastoids and the petrous ridges are also fruitful fields of study

The apparatus used in this mode of study is still expensive and complicated

There is considerable blurring of the adjacent structures and experience is necessary in the interpretation of these types of films The planigraphic examination is not complete in itself and must be used in conjunction with other methods including routine anteroposterior lateral and oblique views and roentgenoscopy The amount of radiation received by the patient is considerable and definitely limits the application of the method Body section roentgenography at present is limited to selected cases While it is hardly likely that it will come into routine use in all clinics laminography has a very definite field of application and as more radiologists learn to appreciate its benefits will doubtless be used more widely in the future

ADDITIONAL READING

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Bronchography —Bronchography is the roentgen demonstration of the bronchial tree with the use of an opaque medium (Figs 50–55) Recent advances in the technical aspects of thoracic surgery and the lowered mortality rates have emphasized the importance of early and accurate diagnosis of pulmonary lesions Bronchography is an invaluable adjunct in the diagnosis of bronchiectasis tuberculosis bronchiogenic carcinoma adenoma foreign body or lung abscess The thoracic surgeon must know the location extent and probable curability of the disease and in these respects bronchography has proven itself indispensable It is possible with proper techniques to visualize each bronchial segment thus enabling the surgeon to decide the manner of approach and the amount of tissue to be resected Many methods of performing bronchography have been suggested and no single procedure has been universally agreed on It is highly desirable that each clinic adopt and perfect a definite routine Only in this way will a complete and satisfactory study be accomplished It is essential that the bronchi be empty at the time of examination This is best accomplished by postural drainage and voluntary coughing with the raising of as much sputum as possible for several hours prior to the examination Retained secretions in the bronchi prevent the iodized oil from entering the bronchioles and result in poor bronchograms The patient should not eat or drink for several hours before the bronchography is to be done Preliminary medication is essential to the success of the procedure The barbiturates are useful to allay nervousness and also appear to serve as a prophylactic to cocaine sensitivity Morphia lessens the cough reflex Atropine decreases the amount of secretion and enhances the effect of the local anesthetic

The anesthesia should be induced and the opaque medium instilled in the roentgen department as moving the patient almost invariably results in unsatisfactory bronchograms Cocaine hydrochloride in 4 per cent solution has proven satisfactory although various derivatives of cocaine may be utilized and are considered preferable by some thoracic surgeons The anesthetic is applied by spray swabbing and injection into the trachea A total of 10 to 15 cc is utilized The throat pharynx piriform sinuses epiglottis and trachea must be anesthetized It is essential to wait until the gag and cough reflexes have been abolished before the examination is begun The opaque medium may be introduced under fluoroscopic control and multiple spot films made during roentgen

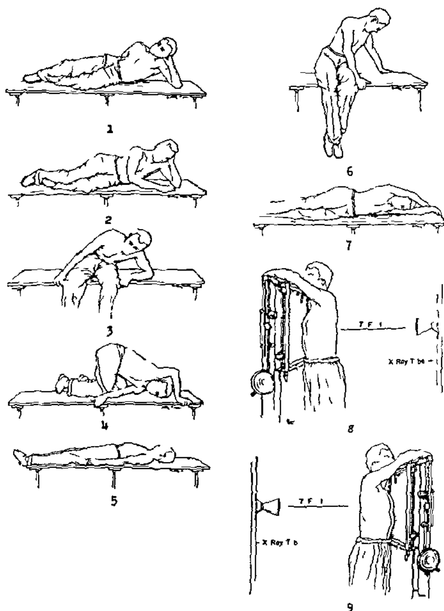


Fig 8 —Positions Assumed During Injection of Iodized Oil in Bronchography

1 Position to fill the left lower lobe bronchus
2 Position to fill the left upper lobe bronchus
3 Position to fill the lingula
4 Position to fill the left apical segment
5 Position to fill the left posterosuperior segment
6 *Position to fill the basal divisions of the bronchi*
7 Position to obtain left lateral recumbent roentgenogram
8 Position for right anterior oblique roentgenogram
9 Position for left anterior oblique roentgenogram

Reproduced by permission of The Journal of the American Medical Association from an article by Adams R H and Davenport L F The Technique of Bronchography and a System of Bronchial Nomenclature J A M A *118* 111 1942

oscopy Stereoscopic studies are very helpful The technique suggested by Adams and Davenport has proven very satisfactory A urethral catheter is threaded on a metal stylet bent to an 80 angle 3 inches from its distal end and introduced into the trachea with aid of a laryngeal mirror The stylet is removed after insertion of the catheter The tip of the catheter should descend to a point about 2 inches above the carina It is not necessary to introduce the catheter into the primary bronchi The patient is then asked to close the lips on the catheter and is seated on a flat top table adjacent to the *x* ray tube and film holder The injection is then performed and the patient is ready for the roentgen examination By having the patient assume the proper positions each of the bronchial subdivisions may be filled by gravity The side of the chest suspected of disease should be studied first If both sides are to be examined it is more satisfactory to inject the left side first The iodized oil is not heated or diluted and is used at room temperature to lessen the amount entering the alveoli In order to visualize each of the segments of the lungs it is necessary for the study to be carried out systematically and the patient must assume a series of positions in a predetermined and definite order (See Fig 10) 1) To fill the left lower lobe bronchus the patient lies on the left side The head and upper portion of the chest are elevated about 30 and turned slightly backward The head is rested on the hand the left arm being flexed and resting on the table Four cc of opaque medium is allowed to flow into the left primary bronchus In this position there is good filling of the dorsal divisional bronchus and the lower lobe segmental bronchi The patient is maintained in this position for one minute to allow complete filling 2) By lowering the head and left upper chest so that they are almost horizontal and injecting 2 cc of oil the left upper lobe bronchus is filled 3) The patient then assumes a sitting position and tilts forward and to the left about 45 Injection of 4 cc of lipiodol in this position permits filling of the lingula 4) In order to visualize the left apical segment the patient assumes a knee chest position with the left arm extending along the table and the right arm over the head The left shoulder and cheek are in contact with the roentgen table 5) To fill the left posterosuperior segments and the left dorsal division the patient turns flat on the back for one minute 6) He then sits up and tilts slightly forward and to the left which permits the opaque medium to flow into the basal divisions of the bronchi A total of 10 cc of iodized oil is injected to obtain complete filling of the left lung To fill the right side the patient is placed on the right side in the successive positions above described and the same procedure is carried out The middle lobe is filled by assuming the position similar to that utilized in filling the lingula on the left The entire procedure requires approximately 15 minutes and 20 cc of iodized oil are used In order to obtain a lateral recumbent roentgenogram the patient lies on the side with both arms extended above the head The roentgen film is placed directly below the axilla and the *x* ray tube 4 feet above the table top The right and or left lateral projections are used as necessary for the individual case The patient then leaves the table and stands before an upright cassette holder The roentgenograms are best made at a distance of 6 to 7 feet target film distance Additional projections are utilized as follows 1) postero anterior 2) anteroposterior 3) right anterior oblique 4) left anterior oblique It is advisable to develop the films immediately and to observe them while wet the patient being allowed to lie quietly on the table Should further roent

genograms be needed they may be made without the use of additional oil If the study is found satisfactory the patient is placed in the head down position and permitted to cough and expel as much of the iodized oil as possible

Excessive filling of the bronchi is to be avoided as a thin coating of the lumen is most satisfactory for diagnosis The alveoli should not be filled The lateral film outlines the posterior and anterior branches and is essential to show the relations of the bronchi It may be advisable to take films both with and without the Bucky diaphragm in order to bring out atelectatic or bronchiectatic areas in the retrocardiac region The right anterior oblique position is most satisfactory for the left side and shows the lingula Similarly the right middle lobe is best seen in the left anterior oblique projection The procedure is contraindicated in cases of active pulmonary tuberculosis acute lung abscess and asthma It must not be attempted in individuals known to have sensitivity to iodine

A universally accepted nomenclature for the bronchi and their subdivisions is greatly to be desired Each lobe is divided into separate divisions (Plate I) The left upper lobe has an apical and lingular division The left lower lobe is comprised of a dorsal and a basal division The right upper and right middle lobes are not separable into divisions as the separation of the right upper and right middle lobes corresponds to the apical and lingular portions on the left The right lower lobe is divided into a dorsal and basal division Each of the divisions are subdivided on an anatomical basis into so called segments or more accurately bronchopulmonary segments which represent the smallest unit of lung tissue of practical diagnostic or therapeutic importance A segment is defined as a subdivision of the pulmonary lobe delimited by a vascular diverging plane which may or may not be indicated by a complete or partial fissure Each bronchopulmonary segment lies with its apex in the hilus and its base occupies an area on the periphery of the lung It is supplied by integra

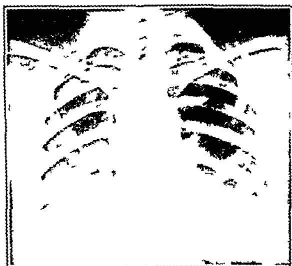
NOMENCLATURE OF THE SUBDIVISIONS OF THE LUNG

Lobe	*Division*	*Segment*
Left upper	Apical	Anterosuperior
		Posterosuperior
		Lateral
		Anteroinferior
	Lingular	Anterolateral
		Posteromedial
Left lower	Dorsal	
	Basal	Anteromedial
		Posteromedial
		Anterolateral
		Posterolateral
Right upper		Anterosuperior
		Posterosuperior
		Lateral
		Anteroinferior
Right middle		Anteromedial
		Posterolateral
Right lower	Dorsal	
	Basal	Anteromedial
		Posteromedial
		Anterolateral
		Posterolateral



Fi 19 Strept coc us Bronchopneum ni with Fluid

There is pneumonia nv lving the left l wer lobe with a mall amount of fluid at the left base The right lung field sh ws mild degree of compensatory emphysema Serologic tud es nd examinat on of the sputum indicated that the pneumonia was due to the tr ptococcus



Fi 0 Br nch pn umonia

There is irregul r m ttled d nsity at b th bases mor n th right The di phragms are hazy nd th co t phren c an les are shall w The pat ent pres nted the ch racteristic cl nical m anifestation of br n h pn um onia

clear The hilar shadows may be enlarged and present irregular indefinite borders There is no lobulation about the lung roots Fluid occurs only rarely (Fig 19) When present it is usually small in amount and limited to the extreme bases or the costophrenic sinuses Encapsulated fluid does not occur as in lobar pneumonia The development of the roentgen changes is not rapid as in lobar pneumonia rather tending to be gradual and more insidious in its course The areas of consolidation may coalesce or remain discrete Patches of broncho pneumonia in the retrocardiac region and at the extreme bases below the level of the dome of the diaphragm are easily overlooked Lateral projections or roentgenograms with the Bucky diaphragm to permit of overexposure may bring into view small lesions which are ordinarily not visualized on the routine projections *and may be of importance in diagnosis It is essential that the roentgen* films be made at the end of a deep inspiration to show small patches at the base

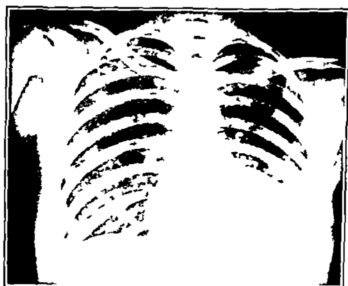


Fig 21 —Bronch pneumonia

There is irregular mottled density in the left middle and lower lung field The density b ure th diaphragm costophrenic angle left heart border and lower ribs The margin f th density are irregular and poorly defined The right base shows less extensive mottlin The apex and upper lung field are unaffected

Repeated studies at intervals of a few days or a week show the progress of resolution the change clearing gradually and the areas of increased density in the lung fields returning to normal radiance Metastatic nodules sarcoid pneumonitis and tuberculosis may easily be confused with bronchopneumonia Metastases tend to become greater in number and size with the passage of time Tuberculosis and sarcoid may increase or remain stationary on subsequent roentgen examination Bronchopneumonia undergoes resolution within a few days or weeks and the progress of the resolution is of great value in differential diagnosis Careful correlation of the roentgen and clinical manifestations is essential for early and accurate diagnosis in bronchopneumonia

Whereas in lobar pneumonia the roentgen manifestations are usually well defined within a few hours after the onset and many hours before the actua

development of clinical manifestations of dullness, rales, and change in the respiratory note on auscultation, bronchopneumonia in most cases is well established clinically prior to the development of definite roentgen manifestations. This is due to the fact that small patches of bronchopneumonia deeply placed in the lungs may not be demonstrable by roentgen methods despite the fact that the disease is well established. It is therefore essential to perform repeated roentgen studies before a final diagnosis is made. The early administration of sulfa drugs and the antibiotics may alter both the clinical and roentgen manifestations and add to the difficulties of arriving at a definite diagnosis.

Pneumonia in Typhus, Rocky Mountain Spotted Fever, and Tularemia.—In typhus and Rocky Mountain Spotted Fever a diffuse bronchopneumonia may occur. The roentgen manifestations are *not* pathognomonic and the diagnosis can be made only by careful correlation of the clinical and the roentgen findings. In tularemia bronchopneumonia may develop. This is particularly apt to occur when the disease is introduced into the lung through the lymphatics. The condition is characterized by marked hilar enlargement, scattered areas of mottled density in both lung fields, engorgement of the lymphatics and prominence of the pulmonary markings extending from the hilus regions to the periphery of the lungs. The areas of density vary widely in size and shape and may be limited to a portion of one lung or be widely distributed throughout both lung fields. The margins of the areas of density are irregular, poorly defined and taper gradually into the adjacent lung tissue.

In another variety of tularemic pneumonia the disease is due to inoculation by aspiration. This form is characterized by massive exudation with large dense areas of consolidation. The roentgen manifestations closely simulate lobar pneumonia. However, the process is not limited in its distribution by the lobar boundries and in this respect is similar to the changes which occur in bronchopneumonia. Abscess formations are common and are due to the presence of areas of focal necrosis. In this variety of the disease the changes are very similar to those which occur in the Friedlander pneumonia.

ADDITIONAL READING

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STUART, B. M., and PULLEN, R. L.: Tularemic Pneumonia. Review of American Literature and Report of 15 Additional Cases. Am. J. Med. S., *10*: 223, 1945.

Bronchiolitis.—Bronchiolitis or capillary bronchitis occurs in infants and is characterized by an intense inflammation of the walls of the bronchioles. There is edema, leucocytic infiltration, narrowing of the lumen of the bronchioles and large amounts of purulent exudate which fill the smaller bronchioles. The process usually spreads to the adjacent alveoli and produces a patchy bronchopneumonia. Clinically the condition is characterized by an acute onset with high fever, constant harassing cough, prostration and cyanosis. Because of the marked obstruction of the bronchioles there is severe labored dyspnea with marked retraction of the soft parts of the chest during inspiration. The physical signs are those of acute emphysema, suppression of the breath sounds and rales. The rales vary in character from sibilant to crepitant and moist and are generalized

throughout the chest The disease is serious and in a large percentage of cases results fatally

The roentgen manifestations comprise enlargement of the hilum glands with diffuse scattered areas of mottled density throughout the lung fields The changes are usually most marked in the parahilar regions and at the bases The unaffected portions of the lungs show moderate degrees of emphysema There is prominence of the linear markings about the hila and at the periphery of the lung fields Patches of atelectasis frequently occur and result in elevation of the diaphragm narrowing of the interspaces and displacement of the heart towards the affected side If the atelectatic areas are bilateral the heart and trachea are not displaced Involvement of the pleura results in a diffuse haziness over the affected portion of the chest This haziness may be generalized and involve the entire lung field or the lower portions of the lung fields alone Fluid usually does not occur The clearing of the pulmonary change is slow the areas of mottling in the lung fields decreasing slowly in size and density In the non fatal cases the protracted resolution eventually results in complete disappearance of the pulmonary changes without sequelae

Bronchiolitis is particularly difficult of recognition by roentgen methods The x ray picture closely simulates that which occurs in sarcoid miliary tuberculosis metastatic carcinoma pneumonoconiosis yeast infections virus pneumonia and numerous other conditions because of the diffuse irregular mottling throughout the lung fields with multiple nodular densities which vary in size from a few millimeters to several centimeters in diameter The changes in bronchiolitis are bilaterally symmetrical and tend to be most marked about the roots of the lungs and at the bases The pulmonary changes may persist for many days or weeks and in consequence differential diagnosis is at times practically impossible Repeated roentgen examinations are essential to establish the diagnosis In the case of miliary tuberculosis yeast infections and similar diseases of the lungs repeated examination shows no change or progressive advance In bronchiolitis there is a gradual diminution and eventual disappearance of the lesions with the passage of time

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PAUL L W Roentgenology Diagnosis of Acute Bronchiolitis (Capillary Bronchitis) in Infants Am J Roentgenol 45 41 1941

Pneumonia due to Bacillus Mucosus Capsulatus (Primary Friedlander Pneumonia) —Friedlander pneumonia is a relatively infrequent yet very important type of pneumonia It is a severe disease in which the mortality is markedly elevated approximately 70 to 80 per cent of cases terminating fatally In the patients who do not succumb there is a high incidence of complications many developing chronic lung abscesses which run a very prolonged course The use of sulfonamides and penicillin has not influenced the mortality in Friedlander pneumonia to an appreciable extent However the early administration of streptomycin has resulted in recovery in some instances with a definite diminution in the death rate As the ordinary types of pneumonia have been greatly reduced in frequency and mortality by modern methods of therapy the more virulent and resistant Friedlander pneumonia has become of increasing importance Early recognition of the disease and the immediate institution of therapy are of the

utmost importance The roentgenologist's ability to indicate the diagnosis or to confirm the suspicions of the clinician may prove of the greatest value As with other rare and unusual conditions the diagnosis will be made only after the demonstration of findings characteristic of the disease and if the possibility of the *condition is borne in mind*

Friedlander first described the bacillus mucosus capsulatus in 1882 and erroneously concluded that this organism was the etiologic agent in the majority of cases of lobar pneumonia Etienne in 1895 recorded early observations as to the prevalence of the Friedlander's bacillus in the respiratory tract of normal individuals and noted the patchy nature of the pulmonary lesions in this type of pneumonia Apelt in 1908 reported a series of cases and stressed the high mortality as well as the tendency to the development of lung abscesses Sisson and Thompson listed 33 cases of primary Friedlander pneumonia in their review of the literature prior to 1915 and added 4 additional cases Zander (1919) reported an epidemic of 411 *cases in a labor camp in Germany This is the largest number* of cases recorded by any author and the only epidemic However a critical analysis by Solomon casts doubt upon the authenticity of these cases as being definitely proved Friedlander pneumonia Julianelle in 1916 classified Friedlander's bacillus into three main types A B and C and a heterogeneous group X by means of agglutination absorption and precipitin reactions and by passive protection tests Belk reported 18 cases all fatal Westmark (1926) observed the tendency of Friedlander pulmonary infection to simulate tuberculosis Kornblum in 1928 and a year later with Collins described the roentgen appearances of Friedlander pneumonia in both the acute and chronic forms He pointed *out the close similarity of the chronic forms to pulmonary tuberculosis and* gave a roentgenologic classification of the stages of primary Friedlander pneumonia Olcott found that in 4 of 6 cases the consolidation at postmortem was lobar in character He noted the occurrence of leukopenia and the high percentage of large mononuclear cells Solomon (1937 and 1940) reviewed both the primary and chronic forms of Friedlander pulmonary infection and included 32 cases of the primary type and 17 of the chronic variety The acute cases were predominately lobar (84 per cent) the remainder being bronchopneumonic in character He indicated the frequency of multilobar involvement the characteristic sputum the leukopenia and the high mortality rate Solomon stated that the *chronic form* of Friedlander infection usually *followed the acute disease* and emphasized the frequency of upper lobe involvement with cavitation findings which usually resulted in an incorrect diagnosis of pulmonary tuberculosis Bullowa Chess and Friedman in 1937 recorded 41 cases of acute pneumonia due to the Friedlander bacillus They quoted French authors who classified the various types as follows 1) the hyperacute characterized by overwhelming toxicity massive consolidation and practically always a fatal termination 2) the *acute type with hepatization* abscess formation and occasional recovery and 3) the subacute or suppurative pneumonic type in which the patient survives the first stage to experience an extended period of remission and exacerbation ultimately developing clinical and roentgenographic evidence of cavitation Bullowa observed that the consolidation was frequently lobar but noted the frequency of extension beyond the interlobar fissure with multilobar involvement Perlman and Bullowa in 1941 recorded 37 cases and stressed the inadequacy of therapy Hyde and Hyde in 1943 reported 51 cases They found the incidence

of Friedlander pneumonia to be 1 6 per cent of the pneumonias at Bellevue Hospital All lobes showed approximately equal frequency of involvement Positive blood cultures were present in 45 per cent of cases The role of streptomycin with penicillin which may be an effective form of therapy for Friedlander pneumonia has been reviewed by Finland *et al* Bishop and Rasmussen Learner and Minnich Welford Geier Nichols and Herrell the Committee on Therapeutics Heilman and others

Etiology —Friedlander pneumonia is more common in males in the ratio of 5 to 1 The majority of cases occur between forty and sixty five years of age only a few instances having been recorded in children A history of alcoholism is often present and is probably a predisposing factor Malnutrition and other debilitating influences are also significant Cold and exposure are important there bein a definitely higher incidence in the winter months There is frequently a history of long standing persistent cough or previous respiratory tract infection with bronchitis and bronchiectasis It has been noted by many authors that a source of infection of the Friedlander bacillus is present in the accessory nasal sinuses the throat or upper air passages In one of our patients elimination of the organism from the sputum was not accomplished until the focus in the sinuses had been eliminated In this type of case there is not infrequently a history of previous attacks of Friedlander pneumonia

Bacteriology and Epidemiology —Friedlander s bacillus was first described in 1882 by Carl Friedlander who considered it the causative organism in most cases of pneumonia With the subsequent demonstration that the pneumococcus was the etiologic agent in lobar pneumonia the pendulum swung to the belief that Friedlander s bacillus was never the cause of pneumonia being merely a secondary invader It is now generally accepted that a small but definite percentage variously estimated at from 0 5 to 5 per cent of all pneumonias are of the primary Friedlander type Friedlander s bacillus commonly referred to as Bacillus mucosus capsulatus is a short gram negative non motile nonspore forming rod with a thick capsule Julianelle in 1926 and 1930 identified two main types A and B Types C D and E and a mixed group X are also described The soluble specific substance of the capsule of Friedlander s bacillus Type B and of pneumococcus Type II are closely related and the sera of one will protect mice against infection with the other Type specific anti era have been found useful in therapy Friedlander s bacillus was demonstrated in the upper respiratory tract of 2 2 per cent of a large group of healthy individuals tested by Bullowa Chess and Friedman The organism may be present in the blood stream and distant metastatic foci occur in the meninges vertebræ and so forth In apparently healthy individuals Friedlander s bacillus has been isolated from the stools urine bile vagina and uterus In addition it has been found in soil air dust mud and water The incubation period is not definitely known but appears short being estimated at about forty eight hours Epidemics are rare although they have been reported The role carriers play in this disease ha not been determined Baehr *et al* believe that primary pulmonary Friedlander infection is rare and that most ca es begin as liver biliary tract and urinary infections the lung being a secondary seat of inva ion oftentimes as a terminal event Study of the literature however indicates that definite primary infection does occur It will be remembered that the pneumococcus streptococcus and other pathogens similarly may appear as saprophytes secondary invaders or in

association with extrapulmonary invaders and Friedländer's bacillus undoubtedly is similar to the pneumococcus in this respect also.

Pathology. — Any lobe or combination of lobes may be involved. Usually more than one lobe is affected. The consolidation is oftentimes described as being lobular or confluent lobular rather than lobar. Solomon reports lobar type of involvement in 84 per cent. He noted involvement of more than one lobe in 65 per cent of his cases. There is apparently no predilection for any particular lobe. The affected lobe or lobes are usually bright red to chocolate brown in color and less frequently pink or grayish. The involved portion of the lung is voluminous. There is considerable inflammatory reaction in the pleura with a reddish fibrinous pleural exudate. The cut surface of the lung is covered with



Fig. 23. — Friedländer Pneumonia. Massive Consolidation Type

There is massive lobar consolidation of the right upper lobe. The affected portion is uniformly dense and bulges downward due to large quantities of exudate. The trachea is deviated slightly to the right. The left upper ribs are almost completely obliterated, indicative of fluid in the alveoli.

viscid, abundant, mucinous exudate which characteristically is very tenacious. The alveolar exudate is usually brick red, glairy, mucoid or gelatinous. Friedländer's bacillus is well known as a destroyer of parenchymal lung tissue. Abscesses filled with pus are of common occurrence. Destruction of the alveolar walls is often found microscopically although it may not be demonstrable grossly. Pulmonary edema, pleural effusion, empyema, pericarditis and meningitis are complications found at autopsy in a high percentage of cases. Portal cirrhosis and fatty liver are probably not infrequent. Jaundice is present in over 10 per cent of acute cases.

Clinical Course. The onset is sudden, usually starting with cough, sputum, hemoptysis, pleuritic pain and a chill. Cyanosis and dyspnea may be present

leukocytosis predominantly polymorphonuclear cells is present Hemolytic streptococcus pneumonia often follows streptococcal infection elsewhere in the body Pharyngitis laryngitis and tracheo bronchitis commonly precede the pneumonia The consolidation is of the diffuse patchy type The sputum is blood streaked or bloody Staphylococcus pneumonias are usually seen in early childhood In adults this type of pneumonia is metastatic from other foci or follows influenza The temperature is high and the consolidation is patchy The sputum is purulent and is usually mixed with varying amounts of blood Influenzal pneumonia is most common in infancy and early childhood In adults it

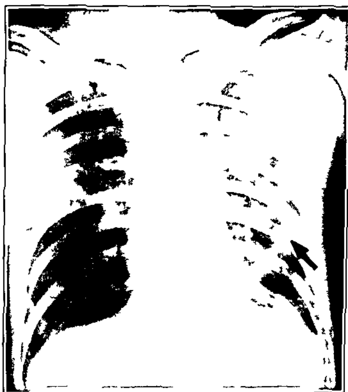


Fig 25 —Friedlander Pneumonia Lobular Type

Roentgen gram on the day of admission to the hospital reveals irregular mottled density throughout the entire left lung field and in the axillary portion of the right upper and mid lung field There is a rounded area of radiance measuring about 4 cm in diameter in the left lung field slightly below the angle of the scapula (arrow) in the region of the seventh and eighth interspaces consistent with a cavitation or abscess formation

occurs in pandemics as in 1918 It may develop in adults after long standing chronic bronchopulmonary infections The virus types of pneumonia are more common in young adults The onset tends to be gradual with headache and a chilly sensation but rarely a true chill Presternal soreness occurs frequently True consolidation is uncommon A peribronchial infiltration usually preading from the hila is seen at roentgen examination Weakness and persistent cough are frequent but severe prostration and death are rare The chronic form of Friedlander pulmonary infection usually with thin walled cavities and abscesses

must be differentiated from the large group of diseases characterized by patchy or peribronchial infiltrations. Pulmonary tuberculosis is usually the first consideration. Some cases of Friedlander pneumonia because of the roentgen demonstration of areas of marked uniform density may be diagnosed as neoplasm of the lung with fluid, atelectasis or both. The history of acute onset, marked toxicity, leukopenia and comparatively low temperature coupled with the inability to obtain fluid on chest tap are important factors in arriving at a correct diagnosis.

Roentgen Findings (Figs. 22–27).—There is no single roentgen picture which occurs regularly in Friedlander pneumonia. Based on a review of the literature and the cases which we have observed, the following roentgenologic classification of this disease is suggested.

Group 1. The Massive Lobar Consolidation Type (Figs. 22, 23, 24).—The affected portion of the lung is markedly and uniformly dense, apparently due to

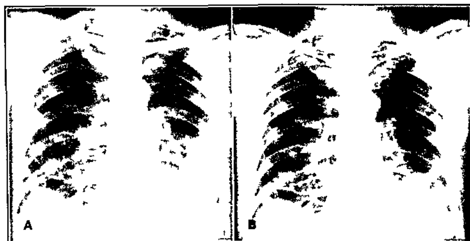


Fig. 26.—Friedländer Pneumonia, Chronic Type with Abscess Formation and Suppuration.

A. Thirteen days after onset. There is diffuse, irregular mottling involving the lower third of the left lung field and the right base. There are multiple small cavitations on the left.

B. About six weeks later. The process is less marked, indicating moderate clearing. There are small cavities at the left base. The right diaphragm is elevated and irregular and the costophrenic angle is shallow and hazy.

very large quantities of exudate. At times a single lobe is involved. In others massive consolidation of the entire lung field occurs. These patients may be seen early in the course of the disease and at that time the dense lobar type of consolidation is fully established, apparently having been present almost from the onset. In some instances the affected lobe(s) seem to bulge, fluid (the so called "drowned lung") being suspected. The impression of fluid is further strengthened when the entire lung field is involved with displacement of the heart and trachea to the opposite side. The density obliterates the outlines of the ribs, the heart border and, when the base is involved, the shadow of the diaphragm and costophrenic angle. The roentgen changes are in practically

every instance interpreted as being due to neoplasm and fluid and the chest is tapped without fluid being obtained. Massive atelectasis may be suspected although the absence of ipsilateral displacement of the heart and mediastinal contents militates against this diagnosis. The cases which present the massive lobar consolidation are practically always rapidly fatal, death resulting from an overwhelming toxicity and in some instances occurring within twelve to twenty-four hours from the onset.



FIG. 27.—Friedländer Pneumonia. Chronic Type with Abscess Formation.

A. Two days after onset. There is an area of marked density in the right mid lung field. The margins of the affected area are sharply defined. The left lung is unaffected.

B. Eleven days later. There is a large cavitation within the involved area.

C.—Same day as in *B*, lateral projection, patient standing. The fluid level in the cavity is clearly demonstrable.

D. Seven weeks after the onset of the illness. The process has cleared markedly and there is now a narrow band of density adjacent to the right hilum.

Group 2 The Lobular Consolidation Type (Fig 25) —In the early stages there is a patchy irregular density which later develops into a confluent consolidation scattered through one or more lobes This group is larger than the massive lobar variety and is usually indistinguishable roentgenographically from other lobular pneumonias This type has a very high mortality rate also although many recover with resolution or continue as the chronic form of Friedlander pneumonia to be described below

Group 3 The Chronic Form Characterized by Lung Abscess Formation and Pulmonary Suppuration (Figs 26 27) —As mentioned above lung abscesses may form relatively early in the course of Friedlander pneumonia They are apparently due to the thick viscid tenacious exudate which produces obstruction with subsequent atelectasis and ischemia Delayed resolution is also a common occurrence with chronic suppuration and abscess formations of varying size which persist for very long periods These changes closely resemble pulmonary tuberculosis or bronchiectasis both clinically and roentgenologically They may undergo partial or complete clearing only to recur despite therapy In some instances the destruction of pulmonary tissue is so extensive that it is referred to as spontaneous lobectomy

It is in the massive lobar consolidation type (Group 1) that the roentgenologist may be of the greatest aid to the clinician Massive consolidation involving one or more lobes should immediately suggest the possibility of Friedlander pneumonia Since death may occur within a matter of hours or days early roentgen diagnosis is of the utmost importance Streptomycin appears effective in some instances while penicillin and the sulfonamides are of doubtful value Prompt institution of therapy may prove a life saving procedure The diagnosis of *chronic Friedlander pneumonia must be considered when the roentgenogram* demonstrates diffuse mottled peribronchial infiltrations with cavitations particularly in cases in which the tubercle bacillus cannot be isolated Although Friedlander s bacillus may be only one of several organisms found the use of streptomycin particularly by the aerosol method may produce beneficial results

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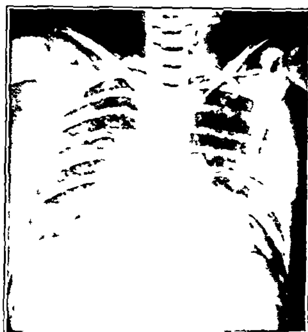
Virus or Atypical Pneumonia, Pneumonitis – The clinical manifestations of virus or atypical pneumonia are very variable Similarly the roentgen findings vary widely in different cases (Figs 28 29 30) There is usually irregular *mottled density involving a portion or portions of one or both lungs There*



Fig 28 – Pneumonitis (Virus Pneumonia)

There is a large irregular area of increased density in the lower third of the right lung field The process is not limited by the lobar boundary The hilus shadows are prominent particularly on the right The right diaphragm is elevated and flattened the lower right interspaces are narrowed and the heart and trachea are deviated to the right indicating atelectatic changes at the right base

may be a single patch or multiple foci may be evident the latter being more common The bases are most frequently affected although the parahilar para cardiac or upper portions of the lungs are also often involved The process is not limited by the lobar boundaries as in lobar pneumonia Irregularity of outline and lack of homogeneity are characteristics of the densities seen in the pulmonary fields in virus pneumonia The hilus shadows are prominent Lateral roentgenograms are particularly valuable in cases of atypical pneumonia to show small patches at the extreme bases below the domes of the diaphragms and in the retrocardiac area Atelectasis is a frequent concomitant occurring in about 20 per cent of the cases and being evidenced by elevation and limitation



Fi 9 — Ireumcniti Virus Ineumcnia

Ih r i diffu irregular m ttlin involvin the middle and lo ver portions of the ri lun h ld nd th l ft b Ih hanes are mc t marked in the paracardiac per f th ri ht l r lun h ld Ihe patient presented the typical clinical manifestati t pn umcn ti



Fig 30 — Ineumonitis

Ther an irregular ar a of mottled den ity at the ri ht ba e in the paracardiac region a pat h f pn um niti

of the diaphragm, displacement of the heart and trachea to the ipsilateral side and narrowing of the interspaces over the affected area. Bronchiectasis rarely occurs in association with pneumonitis.

An important feature of virus pneumonia is a marked discrepancy between the physical and roentgen manifestations. In lobar pneumonia there are definite clinical findings which may be more marked than the roentgen changes, while with virus pneumonia very striking and extensive roentgen densities may be demonstrable in the presence of only slight clinical evidences of disease. Differentiation from bronchopneumonia may be difficult, much more so than in the lobar types of the disease. The clearing of the densities in the virus pneumonias is slow and the roentgen changes may persist for considerable periods, in some cases as long as 3 to 6 weeks after the patient has apparently recovered clinically. Fluid and abscess formation are very rarely seen during or after the virus pneumonias. In practically all cases the disease resolves completely without sequelæ. The mortality is low and the prognosis good. The condition may be confused with lobar pneumonia, bronchopneumonia, tuberculosis, lung abscess, bronchiectasis, metastatic disease, and the virus and rickettsial diseases involving the lungs. The roentgen picture is frequently not pathognomonic and accurate diagnosis is made only by a careful correlation of the clinical manifestations and the roentgen findings.

It must be stressed that the interstitial lesions which occur in atypical or virus pneumonia usually become manifested only after a relatively long interval subsequent to the beginning of the disease. In many cases one, two or more days must elapse after the onset of symptoms before the roentgen manifestations develop. It is true that the physical signs are frequently also delayed and in many instances the roentgen changes are demonstrable before the physical manifestations. After the disease has apparently resolved the roentgen changes may persist, areas of diminished radiance and mottled density being present in the lung fields for days or weeks after the patient is clinically well.

Protozoal Pneumonia.—Protozoal types of pneumonitis are characterized in the early stages by acute pulmonary congestion with prominence of the linear markings, areas of mottled density throughout the lung fields and enlargement of the hilus shadows. After an interval of a few days or weeks there develop multiple scattered areas of mottling and patchy density throughout the lung fields. The changes are most marked about the hila and at the bases. Toxoplasmosis may produce similar manifestations in the lungs. The picture is that of pulmonary congestion. The changes resolve slowly, although in some instances the densities may persist in the lung fields for long periods.

Jaagsiekte.—Jaagsiekte is a virus disease of sheep which rarely occurs in humans. It gives rise to alveolar adenomatosis or alveolar cell carcinoma. In sheep there is a virulent, highly fatal type of pneumonia which is probably due to a virus. There are large cuboidal and columnar cells lining the alveoli and projecting into the lumen in papillomatous fashion. The alveolar cells are arranged in dense fashion with only a small air space remaining. The roentgen examination reveals irregular mottled density throughout the lung fields.

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Rheumatic Pneumonia - In the course of active rheumatic fever with carditis the characteristic pathologic features of rheumatic pneumonia may be observed The clinical picture is manifested by an abrupt onset of marked respiratory distress with absence of corresponding physical signs in the chest hacking cough moderate to high fever and leukocytosis The roentgen changes closely simulate those of pulmonary edema There is a diffuse bilateral multilobular parenchymal mottling which may assume a butterfly distribution A peripheral clear zone of emphysema with varying degrees of obliteration of the vascular pattern of the lung may occur The picture is very closely similar to that seen in uremic edema of the lungs The widespread bilateral multilobular non segmental mottling differentiates rheumatic pneumonia from the bacterial and primary atypical pneumonias

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Ornithotic Pneumonia (Psittacosis) —Ornithosis is usually considered a primary atypical pneumonia of unknown etiology The proper evaluation of this condition has been made possible by the work of Meyer The term psittacosis should be reserved for infections with a proved virus of psittacine origin Ornithosis properly includes human and bird infections due to psittacosis like agent

of non psittacine derivation Human infections are rare because insufficient amounts of the virus are discharged except by ill pigeons and the viruses are of low pathogenicity The disease is usually transmitted by sick birds but human to human transmission also occurs Second attacks of the disease are possible The incubation period is 7 to 14 days with signs of generalized infection developing rapidly thereafter The condition has been classified by Favour into three types First is a very mild form which lasts 1 or 2 weeks The pulmonary involvement is that of a central pneumonia The second a moderately severe type is the typhoidal state The clinical course is more pronounced usually lasting 3 or 4 weeks The pulmonary involvement is central at the onset to later develop into a migrating pneumonitis The process may involve one

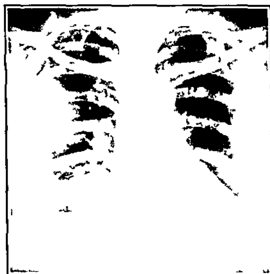


Fig 31 —Ornithotic Pneumonia

There is an area of irregular mottled density in the peripheral portion of the right upper lobe in the region below the clavicle The right hilus shadow is moderately increased in width and density The picture closely resembles atypical pneumonia The patient was a 41 year old housewife with rheumatic heart disease The present illness was characterized by headache fever malaise weakness and dry cough Temperature 103 and pulse 96 The white count was always below [illegible]00 Sulfadiazine had little effect Recovery was prompt Study of the serum showed a diagnostic elevation of complement fixation antibodies for [illegible] The patient had been exposed to pigeons while [illegible] for the birds in a pigeon loft

lobe at first and extend to other lobes on the same or the opposite side The third group is the most severe and has a high mortality approximating 30 per cent The course is more prolonged and widespread pneumonic involvement is characteristic Pleural effusion polyarthritis and peripheral lymphadenopathy may occur Relapses are frequent The most striking feature of the disease is the comparative lack of chest complaints in the presence of widespread roentgen pneumonic changes There is marked weakness and malaise which closely simulates influenza Cyanosis is marked and out of proportion to the extent of lung involvement The white count is low or within normal limits Comple

ment fixation tests for ornithosis are necessary for accurate diagnosis The roentgen picture is that of atypical pneumonia (Figs 31–32) The findings may be those of a central patchy migrating pneumonitis Early lobar pneumonia mediastinal new growth and early lung abscess must be considered in the differential diagnosis

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Fig 32 —Ornithotic Pneumonia Psittacosis

There is a small area of consolidation at the left base in the region adjacent to the left border of the heart a patch of pneumonia

Aspiration Pneumonia —In the past aspiration pneumonia occurred most commonly in children after operations on the throat chest and abdomen in which a general anesthetic was used The condition was due to the inhalation of mucous and infected material from the mouth and throat With modern advances in anesthesiology this form of the disease has become increasingly uncommon and it is now relatively rare Aspiration pneumonia may occur in patients with chronic long standing esophageal obstruction as in carcinoma of the esophagus

and cardiospasm The process is believed to be caused by the inhalation of infected material from the throat and mouth particularly during sleep The pulmonary changes are characterized by multiple irregular patches of increased density scattered throughout the middle and lower portions of the lung fields The areas of density are poorly defined vary widely in size from very small to large and are few or many in number The long standing forms of the disease are frequently associated with pulmonary fibrosis and scattered foci of atelectasis Irregular patches of emphysema frequently occur in the segments of the lung distal to the areas involved in the pneumonia fibrosis and atelectasis Lung abscess is a common complication The abscesses may be small or large and single or multiple Aspiration of blood into the lungs after operations on the throat may produce a picture very similar to aspiration pneumonia and the differentiation can only be made by repeated roentgen study and careful correlation of the clinical and roentgen findings

In carcinoma of the esophagus the development of an aspiration type of pneumonia (Fig 164 p 247) may closely simulate the changes which occur in metastatic carcinoma of the lungs Relief of the obstruction by surgical measures usually results in disappearance of the process in the lungs if the condition is due to aspiration pneumonia Metastatic carcinoma of the lung on the contrary shows rapid progression on successive roentgenograms despite therapy

Pneumonia in Measles, Whooping Cough and Chicken Pox —In measles whooping cough and chicken pox pneumonia frequently develops The roentgen manifestations are those of an aspiration type of pneumonia (Figs 33–34) There is diffuse irregular lobular distribution of patches of density in the lung fields The changes occur particularly about the hila and at the bases The hilum glands are usually enlarged The densities usually clear rapidly and disappear without complications or sequelæ However in long standing cases fibrosis atelectasis and abscess may supervene

The Roentgen Manifestations of Q Fever Rickettsial Pneumonitis — Q fever has been found to be endemic in southern California in the region of Los Angeles and over 300 cases have been recognized in this area Outbreaks have occurred among allied troops in the Mediterranean and the disease has also been reported from Panama Switzerland Texas Chicago and northern California In most instances there is a history of contact with livestock but in many cases no such history is obtained

The causative agent of Q fever is a rickettsia known as coxiella burnetii It is a minute gram negative rod which is resistant to drying chemicals and heat It is recovered from the bloodstream of patients suffering with the disease and also in most of the organs at autopsy The organism is frequently found in cattle and unpasteurized milk There is no person to person transmission The incidence is highest among meat packers laboratory workers studying the condition and those working in or living near dairies The mode of transmission to man is unknown One attack of Q fever confers immunity for a considerable period although relapses may occur during convalescence from the acute illness There are no instances of a second attack The disease is frequently fatal Pathologically the condition is characterized by a diffuse consolidation of the lungs The alveoli bronchioles and bronchi are filled with an exudate which is mainly fibrinocellular and compact The cells consist chiefly of lympho



Fig. 53. Bronchopneumonia in Association with Chicken Pox

There is diffuse irregular mottled density throughout both lung fields, more on the right. The patches are small and confluent at the bases. The hilus shadows are markedly enlarged. The process is not limited by the lobar boundaries. There is no displacement of the heart or trachea. The lung changes developed in the course of a severe attack of chicken pox.



Fig. 54.—Pneumonia in Pertussis. Whooping Cough Pneumonia

There is an area of irregular mottled density at the left base extending from the level of the third interspace anteriorly to the diaphragm. The margins of the area of consolidation are irregular and poorly defined. The pneumonia is of the aspiration type.

cytes plasma cells polymorphonuclears and large mononuclear cells Red blood cells are enmeshed in fibrin and line the alveoli

The disease is most common in adult males but may attack persons of any age The onset is sudden with fever chilly sensations malaise anorexia and severe headaches This is followed in a few days by a hacking non productive cough and pleuritic chest pain The condition is usually diagnosed clinically as primary atypical pneumonia The temperature ranges from 101 to 104 The fever lasts 7 to 15 days the average being 10 days The condition subsides by lysis The pain in the chest and the physical findings correspond to the location of the changes in the roentgenogram Penicillin sulfonamides streptomycin para aminobenzoic acid and roentgen therapy have no effect upon the duration or severity of the illness Aureomycin may prove beneficial Recovery is usually prompt and complete although occasionally the convalescence may be prolonged No complications directly attributal to the disease have been noted The mortality rate is low being approximately 1 per cent The white blood count is usually within normal limits although there may be slight leukopenia or mild leukocytosis The sedimentation rate is elevated in every case The elevation persists for at least 2 weeks during the beginning of the disease The spinal fluid and urine are normal The complement fixation test for Q fever establishes the diagnosis the test becoming positive during the second week of the illness The minimal criterion for the diagnosis of Q fever as stated by Jacobson Denlinger and Carter consists of a blood specimen with a titer of 1 to 32 or greater during convalescence from an acute febrile illness clinically compatible with the disease

Roentgen Findings —In some instances there are no demonstrable roentgen changes throughout the course of the disease In approximately two thirds of the cases there is pneumonic infiltration of varying extent Segmental or lobular consolidation occurs in the large majority of instances and lobar con solidation in a smaller percentage The infiltration may be mottled and con fluent or as scattered patches In some instances a single small patch may be the only manifestation of the disease The disease may involve either lung or any of the lobes Segmental or lobar consolidation is felt to be the most characteristic finding The lesions are most frequently homogeneous in appear ance and more marked towards the periphery of the lung field The density varies from a diffuse cloudiness to a complete opacity Any lobe may be af fected and the involvement may be multilobar When the lesions are multi lobular the changes may be unilateral or bilateral There may be segmental or lobar consolidation of one or more lobes in association with mottled infiltrations and scattered patches in other areas The lesion usually extends by direct progres sion from the initial focus The migratory infiltrations so commonly seen in the atypical pneumonias are not a feature of Q fever Small amounts of fluid may occur but large pleural effusions are rare The fluid is usually a fibrinous exudate The hilus shadows are not enlarged or are increased in only relatively few cases This is in sharp contrast to atypical pneumonia in which hilar involvement is usually the earliest and most common finding Enlargement of the mediastinal glands does not occur Elevation of the diaphragm is rarely seen The pneumonic consolidation appears to come on early in the disease Resolu tion usually begins as the temperature returns to normal Delayed resolution is common In some instances the lung fields show linear strand like shadows after the disease has cleared In many the greater the degree of pneumonic

infiltration the more seriously ill the patient appears to be However patients with bilateral disease are not sicker than those with unilateral disease Chest pain is frequently associated with pleural effusion

Differential Diagnosis —Q fever cannot be differentiated by its symptoms clinical manifestations or roentgen findings from other similar febrile illnesses It is most often considered to be primary atypical or virus pneumonia influenza and meningitis In many instances the patient presents little or no clinical evidence of the disease and the condition may be overlooked The disease should be suspected in any acute febrile episode the etiology of which is not readily established by bacteriologic serologic or other methods While contact with the milk industry or unpasteurized milk is important this is not necessarily present in all instances Similarly it is not possible by roentgen methods to distinguish lobar pneumonia from Q fever Both present segmental or lobar distribution and the course of the disease may be very similar The roentgen picture however is quite different from that in atypical pneumonia In the latter the hilar and vascular shadows are enlarged whereas in Q fever this does not occur While segmental or lobar infiltrations may occur in both atypical pneumonia and Q fever they are more commonly seen in Q fever there being mottled infiltration in atypical pneumonia There are frequently migratory episodes with increase and wandering of the process in atypical pneumonia which does not occur in Q fever Other diseases which may be mentioned as causing somewhat similar roentgen changes include coccidioidomycosis blastomycosis pulmonary tuberculosis and histoplasmosis The absence of hilar and mediastinal lymphadenopathy and cavitations rule out these diseases On resolution the fungous diseases and tuberculosis may leave residuals of rounded discrete foci linear strand like shadows or calcification in the lung parenchyma and regional lymph nodes In Q fever the only residuals are linear strand like shadows Definite diagnosis is possible only by recovery of the causative organisms from the blood stream or the demonstration on successive examinations of the blood of the rising Q fever complement fixation titer An initial negative reaction in the first week of the disease does not exclude the disease

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Chronic Pneumonitis of the Cholesterol Type —There has been described by Robbins and Sniffen a type of chronic pneumonitis which previously has not been recognized in the absence of bronchial obstruction The condition is characterized by a chronic interstitial inflammation with exudate which is composed largely of mononuclear cells filled with cholesterol and esters The cholesterol is present in such high concentration in the parenchyma that the tissue appears bright yellow on gross inspection This type of pneumonitis usually occurs in

the presence of bronchial obstruction and in small localized areas in chronic lesions such as bronchiectasis lung abscess and tuberculosis Robbins and Sniffen state that in their series there was no major bronchial obstruction or significant co existent lung disease in the area of the pneumonitis The condition was found in individuals who had received neither sulfonamides nor penicillin The cases occurred primarily in males of middle and late life Only one was seen in a female a child of twelve The onset was abrupt with pain cough fever and sputum in about half of the patients The remainder showed an insidious onset with a gradual development of cough sputum night sweats weight loss and pain in the chest The sputum varied from mucoid to brownish and there was frank hemoptysis in most cases The duration of the symptoms from the onset to the time of operation was from one and one half months to five years Surgical treatment was instituted because many of the cases could not be differentiated from tumor and even when the diagnosis was established preoperatively there appeared to be continuous extension rather than regression or healing of the process

On pathologic examination the affected lobe was contracted the degree of contraction being dependent on the amount of fibrosis Fibrous adhesions involved all pleural surfaces and were most marked in the region of the lesion The bronchial lymph nodes were very large sometimes reaching a diameter of 2 cm The process involved either the major portion of the lobe or an entire lobe but did not conform to the pulmonary segments in all particulars One pleural surface was involved by the pneumonia in all instances and the inter lobar fissures were usually obliterated In the early phases the pneumonic area was a deep yellow due to close approximation of minute golden yellow globules The primary lobules were indistinct while the secondary lobules were sharply outlined by thick septa With healing the parenchyma became gray and fibrous and the yellow color lessened There were areas of emphysema interspersed between the fibrous bands The larger bronchi in the diseased areas were chronically in flamed and thickened The smaller bronchi showed acute inflammation dilata tion and marked destruction the lumen being filled by mucopurulent material This was apparently due to an acute reaction to recent bacterial involvement and small abscesses were usually present in these areas Microscopic examination revealed large mononuclear cells with a central or somewhat eccentric nucleus in the air spaces of the primary lobules The cytoplasm of the cells contained multiple giant nuclei and was composed of a foam of fine droplets There was a chronic interstitial pneumonitis which began in the connective tissue of the septa and peribronchial and perivascular regions with subsequent involvement of the alveolar walls There was edema with lymphocyte and plasma cell infiltra tion The changes were interstitial and did not form a part of the alveolar exu date The alveolar septal cells were swollen This was followed by a gradual ac cumulation of vacuolated macrophages within the alveolar walls with a consequent decrease of the air space The alveolar walls were widened The tissues appeared to contain a substance within the large monocytes of the air spaces and alveolar walls in the form of fine intracytoplasmic vacuoles This was sudanophilic doubly refractile precipitated by digitonin in fine needles and gave a positive Schultz reaction for cholesterol and cholesterol esters Chemical study of grossly yellow areas in the lungs showed very high values of cholesterol and its esters The process appeared similar to pneumonitis and aspiration pneumonia due to

paraffin oil However there were certain differences in the two conditions as the changes were not identical The origin of the cholesterol is unknown It does not appear to be produced locally The outstanding feature of the pneumonia is *the presence of large deposits of cholesterol in the air spaces and the absence of co-existent lung disease* The process is associated with obstruction of the smaller bronchi or bronchioles The changes may go on to chronic pneumonitis and bronchiectasis It is not known whether it progresses to fibrosis

Roentgen Findings —In most of the cases the roentgen diagnosis was confused with tumor lung abscess or infarct The lesion may be localized to a portion of one or more segments or there may be extensive involvement of a lobe In the latter group there was a moderate amount of collapse The shadow was homogeneous and its shape conformed to the involved portion of the lobe The bronchi did not appear dilated In the patients in whom only a part of one or more segments was involved the segments appeared smaller than normal The involvement was in the region adjacent to the pleura either peripherally or along a fissure The border away from the pleura was rounded or lobulated and sharply defined The bronchi were frequently not visualized but when seen appeared normal or only slightly dilated Thickening of the pleura or pleural fluid hilar and mediastinal lymph gland enlargement and small cavities were occasionally observed

ADDITIONAL READING

ROBBINS L L and SNIFFEN R C Chronic Pneumonitis of Cholesterol Type Proceedings of the N E Roentgen Ray Society 5 28–31 1948

ATELECTASIS EMPHYSEMA LUNG ABSCESS BRONCHITIS BRONCHIECTASIS BRONCHOGRAPHY

ATELECTASIS

The term atelectasis is usually considered to indicate that the lung is collapsed and empty of air Salabarder in an excellent review of the subject states that there is an important difference between the collapsed and the atelectatic lung both from the anatomical and the physiologic point of view In his opinion atelectasis indicates not only the absence of air in the pulmonary alveoli but also an associated intense retraction and shrinking of the lung The shrinking is the important factor which differentiates atelectasis from simple pulmonary collapse in which the alveoli contain little or no air but the alveolar walls are merely flaccid and show no shrinkage This is a conception which must be clearly understood if the pathogenesis is to be understood In atelectasis there is vascular dilatation and the formation of intra alveolar exudate which may be simple edema or hemorrhagic in character There frequently develops an inflammatory reaction accompanied by fever so called atelectatic pneumonia The collapse and its concomitants edema hemorrhagic effusion and pneumonia usually undergo reversion and clearing However if the inflammatory process does not clear promptly desquamation of the endothelium of the alveoli takes place with resultant fibrosis which produces fixation of the parenchyma of the lung

Atelectasis is characterized in every instance by a definite diminution in the size of the lung This decrease in size is more extensive than can be explained by the elasticity of the lung alone The retractile power of the pulmonary tissue is the cause of the negative pressure in the pleural space which usually measures 5 to 7 cm of water It has been determined that when atelectasis is present the negative pleural pressure may become as great as 40 cm of water The narrowing of the interspaces elevation of the diaphragm and ipsilateral displacement of the heart and trachea which occur in atelectasis indicate that there exists a pulmonary retractile force much greater than that of the negative pressure in the pleura alone It was previously believed that bronchial occlusion was the sole cause of atelectasis and that the circulating blood absorbed the air trapped within the alveoli distal to the site of the occlusion causing shrinkage of the walls of the alveoli Atelectasis does occur in association with bronchial occlusion caused by tumors mucus plugs external compressions and scars and the collapse usually disappears when the occlusion is removed by bronchoscopy coughing or similar mechanism However there may be bronchial obstruction without atelectasis Therefore there must be a factor other than or in addition to occlusion of the bronchus to explain the atelectasis especially since there are many instances of collapse without bronchial occlusion

A striking point with reference to bronchial occlusion is that atelectasis results from blockage of a main bronchus but does not develop in the presence of obstruction in a secondary bronchus. Valabarder believes this is due to the fact that in the main bronchus there are zones of sensitivity which do not exist in the secondary bronchi. Hence on manipulation of the primary bronchi parenchymatous reflexes are produced which do not result when the secondary bronchi are similarly affected. The manner of the absorption of the air in the portion of the lung distal to a bronchial occlusion is also significant. The absorption is effected according to the laws of diffusion of gases, the partial pressure and the particular affinity of each of the components being important. A time arrives when an equilibrium is reached and the absorption ceases. At this point a considerable amount of gas still remains in the alveoli and this later is increased by the carbon dioxide of the blood. When the pressure of the gas on each side of the alveolar wall become equal, the alveolar wall is relaxed to the maximum limit which its structure permits. This constitutes the collapsed lung and is quite different from atelectasis. After the pressure within and without the alveoli has become equal the remaining gas in the alveoli can be absorbed only if the alveolar walls compress the air progressively and force it into the capillary vessels. Therefore one must accept Valabarder's hypothesis that the pulmonary parenchyma contract actively in order to explain the complete disappearance of air and alveolar shrinkage in atelectasis. In support of his theory he stresses the fact that atelectasis occur without bronchial occlusion. The gross appearance of atelectatic lung is different than collapsed lung. During inspiration the zone of atelectasis remains motionless and the depression of the zone in relation to the surrounding parenchyma of the lung increases. The patches of atelectasis do not necessarily correspond to the location of the normal fissures except in lobar atelectasis, there frequently being partially dispersed areas of atelectasis which are irregular in form, size and distribution. When atelectasis is large or lobar it may usually be considered as being due to bronchial occlusion. However, smaller patches of atelectasis are not apparently dependent on occlusion of the bronchus.

Atelectasis is common after cranial or thoracic injuries and abdominal operations, particularly if the lumbar or stomach plexus have been damaged. It also occurs frequently at the onset of pleural irritation during pneumothorax and after endopleural manipulations such as cauterization. An example of pulmonary atelectasis without bronchial occlusion is the development of atelectasis by the action of acetylcholine and pleural irritation. Valabarder believes that atelectasis is a reflex active contraction of the parenchyma of the lung and that the reflex may be due to or originate in the abdominal nervous plexus, the walls of a major bronchus, the subpleural space and other areas. It can also originate in the lung itself. In many of these forms of atelectasis bronchial occlusion plays no part. Therefore atelectasis is believed to be produced by active pulmonary contraction and may be the result of any one of several causes acting upon a predisposed organ. Bronchial occlusion while it may be an important factor is not the only cause. Atelectasis consists in the abnormal exaggeration of the physiologic pulmonary tone and this increased tonus is brought about by the action of muscular fibers in the alveolar walls as well as in the smaller bronchi. It is important to distinguish between the usual definition of atelectasis as merely a lung collapsed and empty of air and the new concept that it is not only absence of air but also an intense shrinking and retraction differentiating

from simple pulmonary collapse Bronchial occlusion is not an indispensable factor There is in atelectasis an abnormal exaggeration of the physiologic pulmonary tone Muscle fibers in the alveolar walls under regulation of the autonomic nervous system produce regional contracture in the affected pulmonary zone producing atelectasis

Atelectasis or airlessness of the lung is a finding of major importance which occurs in a wide variety of conditions differs widely in extent and may be the result of one or more of numerous different etiologic factors It may be due to a) extrinsic causes which produce compression of the lung b) bronchial obstruction c) congenital anomalies or d) massive collapse

a) *Compression Atelectasis* —This is the least important and less common type It is seen particularly at the bases in cases with marked elevation of the diaphragm as in ascites subphrenic abscess or marked enlargement of the liver Compression atelectasis may also be present with pleural effusions marked cardiac hypertrophy and at the margins of large pulmonary or mediastinal neoplasms

b) *Obstruction Atelectasis* —Any condition producing bronchial occlusion so that air cannot enter the bronchus produces atelectasis The air in the portion of the lung distal to the point of obstruction is absorbed by the blood with resultant collapse of the lung Because of the decrease in the size of the affected portion of the lung the heart and mediastinal contents are displaced toward the involved area the diaphragm becomes elevated and the interspaces narrowed The occlusion may be due to a mucus plug after an injury operation or the administration of anesthesia inflammatory changes in the bronchial wall tumor foreign body aneurysm and many other causes The obstruction may involve a large bronchus or one or multiple smaller bronchioles While more commonly unilateral it is not infrequently bilateral Emphysema of the compensatory type may develop in the uninvolved portions of the lung and may particularly in children minimize or equalize the displacement of the diaphragm and mediastinal structures Small patches of atelectasis below the diaphragm or in the retrocardiac areas may be demonstrable only in lateral or oblique projections on overexposed roentgenograms made with the Bucky diaphragm or by laminography

Long standing atelectasis may result in abscess formation fibrosis or bronchiectatic changes with consequent alteration of the roentgen and physical findings The onset may occur with dramatic suddenness as in post operative or post traumatic massive collapse producing striking clinical manifestations with chest pain cyanosis and marked elevation of the pulse temperature and respirations which closely simulate pulmonary infarct coronary disease or other serious emergencies It is of the utmost importance for the clinician to bear this in mind as the prognosis in massive collapse is good the condition rarely if ever resulting fatally During the course of a pneumonia sudden shift of the mediastinum and marked increase in the physical signs is an indication that atelectasis has developed Atelectasis may clear slowly or rapidly In some instances alternating clearing and collapse occur one or more times Long standing atelectasis may be manifested by linear strands or plate like densities most probably due to scarring or contraction of an airless patch

Roentgen Findings The roentgen findings are those of an area of density which may be either mottled or uniform in character The margins of the involved seg

mant may be regular or irregular in outline and sharply or poorly defined These changes can simulate fluid or consolidation depending on the extent of the collapse The outlines of the diaphragm ribs and heart border may be obscured or obliterated The heart and mediastinal contents are displaced toward the affected side and there is usually narrowing of the interspaces because of the diminished volume of the lung These changes establish the diagnosis of atelectasis Displacements of the interlobar septa are an important aid in the diagnosis and localization of atelectatic area Compensatory emphysema of the involved portion of the lung produces increased radiability As indicated above lateral and oblique roentgenograms are essential to localize small retrocardiac or basal lesion An overexposed film or one made with the Bucky diaphragm may produce valuable additional data by outlining the elevated diaphragm or displaced heart

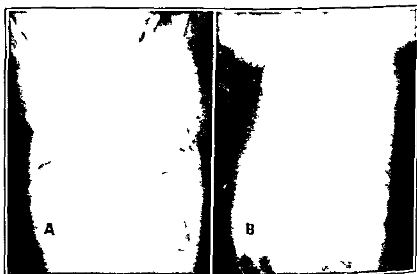


Fig — Atelectasis of the New Born

A Th r i m rkedly in re ed density throughout both lung fields with ab ence of the lin ar marking Th d n ity in th lung fields i so marked that the outline of the heart nd gr at es l ann t b di tingui h d The patient is a new born infant with pra ti ally mpl te at l ta f both lungs *There are large amounts of gas in the stomach and the* intestines

B L teral Fr je ti n There is slightly increased radiance in the r trosternal and retrocardi ar a ndicating p rtial aeration of the lungs The patient expired hortly at l ecta s f thi degre usually not being compatible with life

border Bronchography afford a means of localizing the point of obstruction and in many cases demonstrates the etiologic factor in chronic atelectasis The position of the diaphragm in atelectasis involving the left lower lobe may be determined by the administration of a barium meal carbonated water or a small portion of a eidlitz powder prior to the roentgen study The clearing of the atelectasis may be observed by serial roentgenograms at interval of a few days The demonstration of a foreign body abscess aneurysm neoplasm or other cause of the atelectasis is always of the greatest importance to the clinician and urgeon in planning therapy or arriving at a prognosis

c) *Congenital Atelectasis* In congenital atelectasis there may be lack of expansion of the peripheral portions of the lungs or partial or complete atelectasis of one or both lungs (Fig 35) The condition is associated with cyanosis and dyspnea at birth or during the first few days of life When bilateral there is absence of lung markings at the peripheral and/or basal portions of the lung The unilateral cases produce findings as described above When marked there may be herniation of the unaffected lung into the involved hemithorax because of the marked compensatory emphysema of the lung

d) *Post operative Massive Collapse of the Lungs* Atelectasis of the lungs may occur in varying degrees in association with several different kinds of pathology



Fig 36 Atelectasis Massive Type

There is massive atelectasis in the left The entire left lung field is occupied by uniform density which obliterates the outlines of the borders of the heart the great vessels the ribs the diaphragms and the costophrenic angles The density is similar in character to that in fluid However the marked deviation of the heart and trachea indicate that there is atelectasis rather than fluid There is compensatory emphysema on the right evidenced by increased radiability of the lung field widening of the interspaces and depression of the diaphragm The condition came on acutely 12 hours following an appendectomy The onset was sudden with dyspnea cyanosis chest pain elevation of the pulse and increased temperature The atelectasis cleared completely re-examination two weeks later showing no evidence of disease in the lungs

But excluding the congenital and pressure cases (pneumothorax effusions and tumors) atelectasis of whole lobes of the lung occurs only 1) in the presence of diaphragmatic paralysis (infantile or diphtheritic) 2) under certain conditions in the presence of intra bronchial foreign bodies and 3) following certain injuries or operations not involving the lungs or pleura For this last group of cases the formidable name Massive Collapse of the Lungs has been used since W Pasteur s original work It will be evident at once in studying the physical

sign and roentgenogram that this condition is very different from the ordinary post-operative pulmonary complications such as bronchitis bronchopneumonia infarcation abscess or pleurisy Massive collapse has been reported after injuries of various types and after surgical operations It has been seen in operative cases with general anesthesia local anesthesia or even no anesthesia. The collapse may involve an entire lung lobe or portion of one or more lobes on the same or opposite sides



Fig — Atelectasis of the Right Lower Lobe

There is irregular mottled density involving the lower third of the right lung field The right diaphragm elevated and fixed The right costophrenic angle is shallow The heart and trachea are deviated markedly to the right The left lung field shows a moderate degree of compensatory emphysema The patient had an appendectomy 5 days previously The atelectasis developed suddenly with pain in the chest cyanosis rapid pulse elevation of temperature and rusty sputum The clinical picture closely simulated that of pneumonia Roentgen examination established the diagnosis of atelectasis The atelectasis cleared within a week with complete recovery

The onset is usually sudden and occurs from a few hours to several days after the injury or operation It is characterized in some cases by a sensation of pain or tightness in the chest cyanosis and dyspnea In other cases there are few or no symptoms the condition being discovered only on physical or x-ray examination of the chest There is usually a cough from the onset This

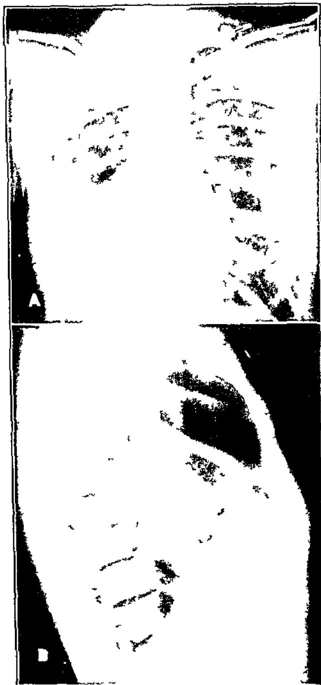


Fig. 58 Atelectasis Right Middle Lobe

A There is an area of uniform density involving the lower third of the right lung field The heart and trachea are deviated markedly to the right The interspaces on the right are narrowed The left lung field shows a moderate degree of emphysema

B Lateral projection The process is localized to the middle lobe the density occupying the anterior and inferior portion of the lung field

unproductive and quite troublesome at first The signs that establish the diagnosis are dullness to flatness of the base of one lung associated with great displacement of the heart toward this side The position of the heart is recognized by palpation of its impulse and by percussion Confirmatory signs are comparative immobility of the affected side of the chest during respiration with retraction of the interspaces There may be hyperresonance of the opposite side The breath sounds are usually diminished and of vesicular character Loud tubular breathing has been reported in some typical cases Rales are usually absent at first but later with the onset of productive cough many fine and coarse rales appear The temperature pulse and respiration all increase at first but never to the degree that they do in pneumonia infarcation or pleurisy

On x ray examination there is markedly diminished radiance over the affected portion of the lung the dullness may be somewhat mottled in character (Fig 36 38) The heart and trachea are markedly displaced to the affected side The diaphragm merges with the dullness above it and its outline is obliterated at first As the chest clears the diaphragm on the side of the collapse is found to be elevated and its respiratory excursions are diminished or absent

The duration varies from one day to a week or ten days Recovery is usually gradual although it may be sudden and spectacular all of the signs clearing within a few hours Ordinarily however there is a gradual decrease of all the symptoms and signs with development of rales and mucoid or muco-purulent sputum The heart and mediastinal contents gradually return to normal position The diaphragm remains elevated and its respiratory excursions are limited even after all other signs have disappeared A striking feature of these cases is that at the height of the process with large portions of the lung not functioning the patients are not toxic and frequently do not know that there is anything wrong The prognosis is in general good whereas in the conditions that simulate collapse such as post operative lobar pneumonia edema or massive infarcation the prognosis is grave This makes the recognition of collapse important

The diagnosis of massive collapse of the lung is usually made without difficulty if this condition is borne in mind by the examiner The sudden onset with pain or tightness in the chest dyspnea and cyanosis points immediately to a pulmonary complication and the immobility of the affected side together with the dullness and the displacement of the heart toward the affected side make a picture which is quite distinctive and not easily confused with other pulmonary complications The conditions which should be considered in the differential diagnosis are as follows pneumonia embolism and infarcation acute pulmonary edema pleural effusion empyema hemothorax subphrenic abscess and foreign body in the bronchus

In lobar pneumonia the temperature pulse and respiration are elevated to a greater degree than is usually the case in massive collapse The onset with chills the typical pulse respiration ratio rusty sputum and sudden termination by crisis are also quite characteristic in cases of pneumonia It is moreover well recognized that true lobar pneumonia is an infrequent post-operative complication In pneumonia there is no marked displacement of the heart and consolidation is usually sharply limited by all boundaries of the lobe whereas in massive collapse there is very marked cardiac displacement and usually a lack of correspondence between the areas of dullness and the lobes of the lung

In embolism and infarction the sudden attack of dyspnea pain and prostration may simulate massive collapse However the physical signs are quite different and with the aid of the x ray examination there is usually no difficulty in differentiating the two conditions Acute pulmonary edema likewise begins with oppression and pain in the chest dyspnea and orthopnea This is soon followed by an incessant short cough with much serous frothy often reddish sputum and many fine rales are heard over both chests which is quite different from the course of events in massive collapse Pleural effusion can be ruled out by the fact that the displacement of the heart is away from the dull side instead of toward it as in massive collapse the same of course applies to hemothorax and empyema In subphrenic abscess developing soon after abdominal operations or wounds the signs and symptoms may simulate massive collapse The course however is so different and the x ray picture so unlike that of massive collapse that there is but little likelihood of confusion

A foreign body in a bronchus may cause complete obstruction with resultant absorption of the air in that portion of the lung supplied by the bronchus This of course exactly duplicates the conditions of Lichtheim s experiment in which the bronchus was plugged by a laminaria plug causing complete occlusion following this the air contained in the lung was absorbed into the blood stream and collapse ensued The signs in cases of foreign body with complete occlusion will of course be exactly the same as in typical post operative massive collapse The history of the case would make the diagnosis clear as would also he demonstration of the foreign body by the x ray if it were opaque

The mechanism of the collapse is still subject to debate Lichtheim showed hat collapse will ensue if a bronchus is plugged His experiments also demonstrated that with the bronchus plugged collapse does not ensue if the blood vessels to that lung are tied His first point has been amply shown clinically in the ase of foreign bodies that cause complete occlusion However there is no oreign body to seal the bronchus in these cases Pasteur thought massive collapse was due to reflex paralysis of the diaphragm That the diaphragm is fixed n these cases is shown by serial radiological examination But we think that his is an effect and not a cause of the disease The many contralateral traumatic ases reported by Bradford are difficult to explain by this theory Briscoe in 919 presented anatomical and experimental work which showed that there always a certain degree of atelectasis at the bases of the lungs in recumbent atients We think most observers will agree to this but he then explained the nassive collapse cases as due to an active inflammation of the diaphragmatic leura which caused a reflex paralysis of the diaphragm on the side of the nflammation However this has not been borne out by clinical facts Reflex pasm of bronchioles has al o been brought forward as a cause We think this inadequate for the same reasons as Pasteur s theory Others on the contrary hink it due to plugging of the bronchi with mucus which the patient is unable to xpel as a result of his wound and recumbent position Clerf recently described e course of a case that following tracheotomy needed bronchoscopy seventeen mes for the removal of mucus The signs and symptoms in this case were pical of collapse of the lung and due to bronchial obstruction from the mucus he cough reflex was diminished and made ineffective by the tracheotomy

We believe that the condition i determined by plugs of mucus in bronchi e recumbent posture and protective muscular spasm re ulting from the wound ing important predisposing factors Once absorption of air behind a plug has

started a vicious circle is initiated for with the smaller amount of air a proportionately greater muscular effort is necessary in a cough to create enough pressure to dislodge the plug

The prevention of collapse should be along lines that would hinder the formation of mucus in the bronchi and would promote expansion of the bases of the lungs during and after the operation After the collapse is established symptomatic and expectant treatment is indicated During the stage of expansion breathing exercises and blow bottles may hasten the course somewhat It was pointed out by J R Bradford that above all these cases must not be explored or even tapped under a mistaken diagnosis of fluid as the sudden change in pressure may prove fatal

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Emphysema or hyperaeration of the lung may be localized to a portion of the lung but is more commonly generalized

Localized Emphysema This type is seen in the presence of ball valve type of foreign bodies which allow air to enter but not to leave a portion of the lung certain neoplasms which produce a similar result and in compensatory emphysema when one lung or portion of the lung is not functioning because of atelectasis The emphysema may change rapidly or with a non fixed foreign body which moves from one portion of the lung to another may shift to different segments of the pulmonary field In pneumonia neoplasm and lung abscess localized areas of emphysema may occur in the lung field adjacent to the lesion

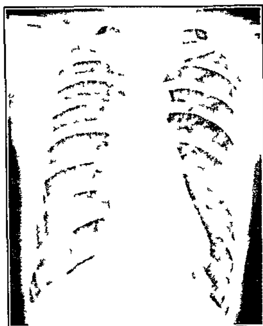


Fig 39 —Emphysema

Both lung fields show generalized increase in radiance The linear markings are prominent particularly about the roots of the lungs and at the bases The diaphragms are depressed and flattened There is widening of the interspaces The heart shadow is long and narrow and occupies a vertical position in the chest The entire heart is visualized when normally the apical and extreme lower portion of the heart are obscured by the diaphragm

Generalized Emphysema (Fig 39 40) In generalized emphysema both lungs are involved the bases often showing more marked changes than the middle or upper portions of the lung field The roentgen findings in the sagittal projec

tion are those of markedly increased radiability of the lungs the roentgenogram at first glance giving the impression of having been overexposed The chest is long and narrow The diaphragms are low flattened and their respiratory excursions are limited The costophrenic angles are shallow The interspaces are widened The heart shadow is vertical and the extreme lower portion of the cardiac silhouette and the apex which are normally not seen because of the overlapping of the diaphragm may be completely visualized In many cases the heart seems small because of its vertical position With long standing emphysema associated with obstruction to the blood flow in the lungs because of chronic pulmonary fibrosis there is enlargement of the right auricle and



Fig 40 — Emphysema Lateral Projection

Roentgenograms of the chest in the lateral projection are of great value in the study of emphysema and demonstrate increased radiability in the retrosternal area and retrocardiac region The anteroposterior diameter of the chest is increased and the sternum bulges anteriorly

ventricle increase in the transverse diameter of the heart and enlargement of the pulmonary artery resulting in a bulge or prominence immediately below the outline of the aortic knob The shadows of the hila the bronchi and the blood vessels are very sharply delineated and extend to the periphery and basal portions of the lungs In long standing cases with chronic infection and consequent fibrotic changes there is distributed throughout the lung fields more particularly in the paracardiac and basal regions a strand like network of fine interlacing lines which is almost uniform in character Pleural adhesions with tenting and irregularity of the diaphragm and irregularities of the pericardial and mediastinal

contours may be present. The costophrenic sinuses may become shallow or obliterated. The fissures are frequently outlined by dense irregular linear bands. There is increased radiability along the lateral margins of the mediastinal shadow due to overlapping by the distended hyperaerated lung.

Lateral roentgenograms are of particular value in emphysema and afford valuable additional data (Fig. 40). There is increased anteroposterior diameter of the chest with outward bulging of the sternum, particularly in its upper and mid portions. The retrocardiac area is widened and shows markedly increased radiance, especially at the base. The diaphragms are low and flat. There is increase in the amount of lung tissue lying under the sternum as well as behind the heart and aorta. Bronchography with iodized oil may give valuable data.

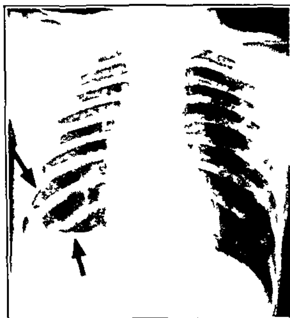


Fig. 41.—Emphysema with Large Bleb

The patient has chronic emphysema with bronchitis and bronchiectasis. There is an area of radiance at the right base, an emphysematous bleb, extending from the level of the eighth rib posteriorly to the diaphragm (black arrows). The margins of the bleb are narrow and sharply defined. There is no reaction in the adjacent lung and no evidence of a fluid level.

The smaller bronchi are not outlined and show absence of arborization. The larger bronchi are dilated.

Blebs. Large blebs are very prone to occur (Figs. 41–42). These present characteristic roentgen manifestations with an area in which the linear markings are entirely absent or nearly so. This area is more radiant than the adjacent lung and present a rounded ring like margin of linear density. The blebs occupy a large segment of the pulmonic field and may overlap the heart and mediastinal shadow. Small bullae may occur in groups and produce a honeycomb appearance or closely simulate lung abscess. However, these bullae occur most often at the

bases near the periphery; hence the differential diagnosis is usually not difficult.

Patches of atelectasis may occur giving areas of increased density. Plate atelectasis is not uncommon and is manifested by oblique or horizontal strandlike densities in the lung field. In allergic emphysema there is enlargement of the hilus shadows, prominence of the bronchovascular markings and in many instances scattered patchy areas of atelectasis. The changes may be more marked on one side than the other although this is unusual. Paradoxical changes in the size of the heart may be demonstrable fluoroscopically in cases with acute marked bronchial obstruction.

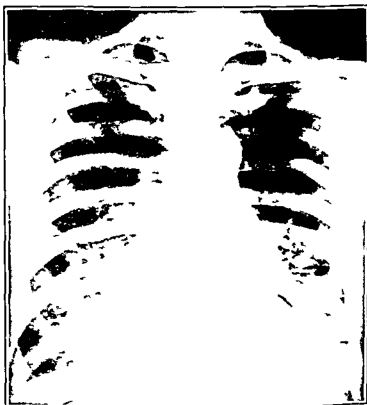


Fig. 42.—Large Emphysematous Bleb

The upper and mid portions of the lung field show markedly increased radiance with absence of the lung structure due to the presence of large emphysematous blebs. There is diminished radiance with prominence of the markings in the middle and lower lung fields more on the right due to peribronchial thickening. Impression: atelectasis and bronchiectasis.

LUNG ABSCESS

In lung abscess roentgen examination is important in the diagnosis localization and study of the progress of the lesion Acute abscess of the lung may

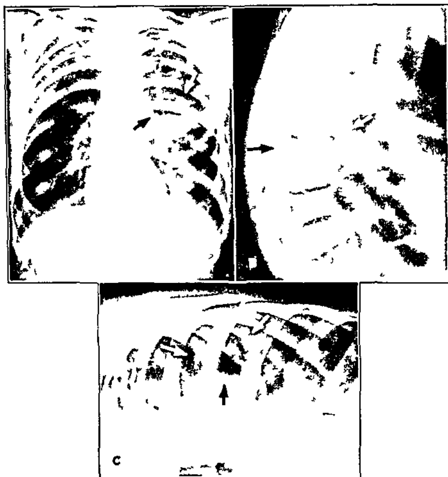


Fig 43 Lung Abscess

A There is a round area of density in the left mid lung field adjacent to the hilum The margins of the area are irregular (white arrow) There is a fluid level (black arrow) in the midportion of the abscess with air above the fluid

B Lateral projection The abscess lies in the posterior aspect of the chest and is partially obscured by the shadow of the spine The fluid level is indicated by the black arrow The abscess lies in the apex of the left lower lobe (white arrow)

C Lateral decubitus patient on the right side with the film anteriorly There is a horizontal fluid level within the abscess (black arrow) The wall of the abscess is dense and irregular (white arrow)

resolve spontaneously and serial roentgenograms are essential to observe the healing. In the chronic form operative interference is practically always necessary. The surgical approach must if at all possible be made at the point where the abscess comes in contact with the periphery of the lung in order to prevent spread of the infection and resultant empyema. Clinical observation is of little avail in determining the advance or healing of lung abscess, frequent roentgen studies being the only accurate method of following these changes.

Early Stages. —In the early stages the roentgen picture is that of an area of mottled density with irregular poorly defined borders as in a patch of pneumonia. The lesion is most commonly seen in the superior aspect of the lower lobe. As the abscess is in most instances adjacent to the periphery of the lung a localized pleuritis develops. Atelectasis of varying degree is not infrequently present because of bronchial occlusion and produces a shift of the mediastinal structures toward the affected side and narrowing of the interspaces over the involved area. As the lesion becomes chronic it communicates with a bronchus and a cavitation develops in its central portion. The appearance of the cavity varies with the stage of the disease and whether or not it is filled with fluid (Fig. 4). If the abscess is completely full of fluid it is visualized as an area of uniform density in its central portion, the margins being irregular, poorly defined and tapering off gradually into the adjacent lung tissue. When the cavity is empty there is a shadow of increased radiance surrounded by a ring like clearly demarcated margin which represents the walls of the lesion. A partially filled abscess presents a horizontal fluid level with the patient upright. This level shifts when the patient is tilted and in the lateral decubitus position the level remains parallel to the sagittal plane (Fig. 44). As the process becomes more chronic its walls are increasingly thicker, denser and more clearly differentiated from the adjacent pulmonary shadows.

Healing. —Lung abscess which heals spontaneously may disappear completely or leave only a few fibrous strands. Recurrences are common and must be sought for carefully by repeated roentgen studies. Chronic cases tend to spread by direct contiguity to the adjacent portions of the lung and into neighboring lobes through the bronchial tree. Large amounts of fibrous tissue are present about the margins of a long standing abscess and bronchiectatic changes develop in these areas resulting in confusion in diagnosis. Perforation of an abscess into the pleural cavity produces a pyopneumothorax with the accumulation of fluid and air in the pleural cavity. This is evidenced roentgenographically by a fluid level with an air shadow above, the level shifting with change in position of the patient.

Localization of Lung Abscess. —The localization of the lesion is important from the surgical point of view and is best made by roentgenoscopic study. As abscess of the lung always lies in close relation to the bronchi it is essential to bear in mind the configuration of these structures. The upper lobes are similar except that on the left the lingula corresponds to the middle lobe on the right. In the two lower lobes the arrangement of the bronchial division is also identical. The first division extends posteriorly to subdivide into several branches in the apical region. There may in some instances be a smaller branch directly below the first division which extends laterally and inferiorly into the infrapical segment. The main lower lobe bronchus then subdivides into four terminal branches (1) the inferior paravertebral adjacent to the spine (2) ...

mesial which may branch from the lower paravertebral supplies the paracardiac area (3) the posterolateral lateral to the inferior paravertebral segment and (4) the anterolateral division supplying the axillary diaphragmatic and anterior aspects of the lobe The bronchus to the right middle lobe arises from the anterior aspect of the right lower lobe bronchus extends anterolaterally and divides into an axillary and anterior division





Figs 44 and 45 —Lung Abscess

Studies made in the right and left lateral decubitus positions reveal a lung abscess in the right upper lobe There is fluid in the middle and lower portions of the abscess cavity with air above The periphery of the abscess is dense irregular poorly defined and fades off gradually into the surrounding lung field

Fig 44 —With the patient lying on the right side the air in the abscess cavity is adjacent to the shadow of the spine (white arrow)

Fig 45 —In the left lateral decubitus position the air within the abscess rises to the peripheral portion of the lung in the axillary region (white arrow)

Bronchography in Lung Abscess – Bronchographic study is of great aid in the localization of a lung abscess. Usually the opaque medium does not enter the abscess cavity because of the inflammatory reaction in the involved bronchi, the abscess being located in that portion of the lung which is not completely outlined by the iodized oil. Bronchiectatic changes are usually demonstrable in the lung adjacent to the abscess. Multiple small abscesses often occur in staphylococcus pneumonia and as a sequel to infected emboli. These may show areas of increased radiance due to cavitations and lipiodol injection is frequently successful in outlining the cavities.

Lung abscess occurs frequently in association with primary carcinoma of the lung and may in some instances be the first manifestation of the disease. The discovery of a lung abscess without a previous history which could explain the origin of the lesion should always lead the observer to consider the possibility that the patient has a bronchiogenic carcinoma and that the abscess is the first manifestation of the more serious underlying disease. In Friedlander pneumonia, lung abscess is a frequent complication. The presence of delayed resolution and abscess formation in a long drawn out case of pneumonia are important aids in establishing the diagnosis of pneumonia due to the bacillus mucosus capsulatus.

Differential Diagnosis – Differential diagnosis must include tuberculous cavities, actinomycosis, coccidioidomycosis, localized pneumothorax and cysts of the lung. Tuberculous cavities tend to occur in the upper lobes, do not show fluid levels, have thinner and more clearly defined outer borders, are commonly multiple and usually occur in association with other evidences of pulmonary tuberculosis. In actinomycosis there is in most instances rapid extension of the process with associated destructive changes in the ribs, vertebræ and other adjacent bony structures and fistula formation. Coccidioidomycosis affects patients who have been in the San Joaquin Valley region and the history is of importance in arriving at a diagnosis. Pulmonary cysts are larger, have thin, sharply defined wall and present less mottling and infiltration in the adjacent lung tissue. Infected lung cysts may have a fluid level much as in lung abscess but are more apt to show rapid changes in size than lung abscess. Localized pneumothorax when infected presents a fluid level as in abscess, the area at the pleural surface and presents complete absence of lung markings.

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BRONCHITIS

Bronchitis occurs in an acute and a chronic form. Acute bronchitis is an inflammation of the tracheobronchial tree caused by infectious, physical or chemical agents. It is commonly seen in whooping cough, measles, typhoid, typhus, diphtheria, the mycotic and parasitic diseases, particularly coccidioidomycosis, moniliasis, trichinosis and similar conditions. Allergic factors are important in the etiology of bronchitis. Physical and chemical irritants are a frequent cause of bronchial irritation and inflammation. Bronchitis may develop subsequent to the inhalation of hot fumes or toxic gases and severe burns. The war gases, particularly mustard and chlorine, and the inhalation of strong acids, ammonia, and other irritant gases may produce bronchitis. The condition is usually self limited, running a short course with eventual return to normal structure and function. The process is usually part of a general upper respiratory infection. The larger and medium bronchi are involved and there is rarely extension to the lung parenchyma. The chronic forms of the disease are associated with inflammatory, fibrotic and atrophic changes in the mucous membranes and the deeper bronchial structures. There is frequently pulmonary fibrosis, emphysema and other associated pulmonary disease. The lesion is due to low grade chronic infection, poor pulmonary drainage, inadequate circulation and nutrition of the tissues and similar factors. Chronic bronchitis may be localized or diffuse. It is seen in most cases of pulmonary fibrosis, obstructive emphysema, asthma, bronchiectasis, chronic sinusitis and congestive heart failure. Inadequate bronchial drainage as in marked kyphoscoliosis, bronchiectasis, tuberculosis or narrowing and compression of the bronchial lumen from aneurysm or tumor is frequently associated with chronic bronchitis. Inhalation of irritant inorganic dust is a frequent cause.

The acute cases are usually bilateral, although the involvement may be more marked on one side. The larger and medium bronchi are most commonly involved. The bronchial lumen contains large amounts of sticky or mucopurulent exudate. The chronic forms of bronchitis show thickening and loss of elasticity of the bronchi. The epithelium of the bronchi is abnormal in shape and there is much desquamation of the cells. Varying degrees of peribronchial inflammation are present. The lesions consist of inflammation and chronic infection of the mucous membranes with the accumulation of exudate due to poor bronchial drainage. There is loss of elasticity and rigidity of the bronchiolar structures with varying degrees of obstruction of the air passage. Under normal conditions the trachea and the bronchi are capable of eliminating bacteria and small foreign bodies which gain entrance with the inhaled air. The mechanism by which this is accomplished is dependent on the ciliated bronchial epithelium which has the power of carrying small foreign particles from the bronchi and bronchioles to the throat. The pulmonary lymphatics and the phagocytic cells aid in this process. Cough has an important function in the elimination of secretion and foreign material from the lungs. Below the level of the larynx the pulmonary tissue is practically free of bacteria and foreign material under

BRONCHIECTASIS

Bronchiectasis is an abnormal dilatation of the bronchi or bronchioles. The changes may be localized or widespread. Secretions collect in the dilated bronchioles and are expectorated at varying intervals as large amounts of foul smelling material. The condition is caused by a weakening of the bronchial wall, most often as a sequel to infection. The elastic and muscular tissues become atrophied and fibrosis may occur although in many instances there is no evidence of fibrotic changes. The bronchial tree dilates during inspiration and contracts in expiration. The contraction is aided in great part by the elastic tissue. With atrophy of the elastica the power of contraction becomes lessened and the



Fig. 47 — Bronchitis and Bronchiectasis

There is prominence of the linear markings and diffusely diminished radiance at the bases. There are multiple small rounded areas of increased radiance throughout both lower lung fields indicative of bronchiectasis.

tubes remain dilated to a greater or lesser degree during expiration. Increase in the size of the bronchioles to a point greater than normal is explained by the fact that in inspiration the pressure in the bronchi is greater than that in the thoracic cavity and the extrabronchial pulmonary tissues. In expiration the pressure within the bronchi cannot exceed that in the adjacent tissues, hence coughing cannot, despite the resultant rise in intrapleural pressure, produce bronchiectasis. Atelectasis, whether massive or lobar, is associated with increased negative pressure in the thoracic cavity and favors the development

of bronchiectasis Partial bronchial occlusions which permit inspiration while hindering expiration tend to result in bronchiectasis This explains the development of bronchiectasis in the presence of a long standing foreign body in the bronchioles Since bronchiectasis is frequently seen in the absence of fibrosis it is accepted that the weakening of the bronchial wall is the important factor in the pathogenesis of bronchiectasis and that fibrosis is a secondary manifestation

There occur in association with the dilatation other changes in the bronchial wall which vary with the stage of the process and may be inflammatory destructive or reparative in nature The disease occurs in three forms characterized as cylindrical saccular and cystic and is limited primarily to the peripheral

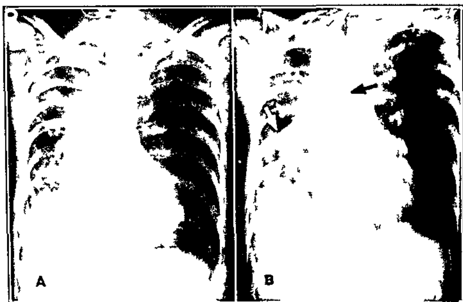


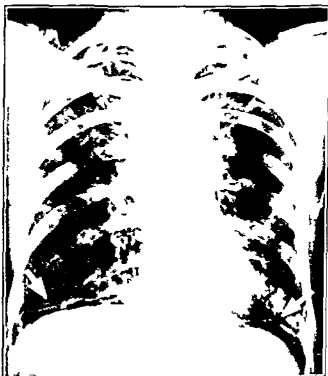
FIG 48 —Chronic Bronchiectasis with Atelectasis and Emphysema

A Sagittal Roentgenogram There is irregular mottled density in the infraclavicular region and the paracardiac portion of the right lower lung field The heart and trachea are deviated markedly to the right The right diaphragm is elevated and hazy The right costophrenic angle is obliterated There is marked narrowing of the right interspaces The left lung field is emphysematous The left diaphragm is depressed

B Laminogram Depth 7 cm The bronchiectatic cavities in the paracardiac portion of the right lower lung field are visualized as multiple small rounded areas of radiance with thick walled septa (white arrow) The deviation of the trachea and the carina are more clearly visualized than in the conventional roentgenogram (black arrow)

bronchi the major divisions showing little or no involvement It is characterized by destructive changes in the bronchial walls In most instances the changes are the result of infection or the inhalation of irritant fumes and other chemical agents injurious to the lung No single organism or group of organisms has been identified as the causative factor Chronic pulmonary suppuration and destructive inflammation of the bronchial wall frequently lead to bron

chiectasi The change occur particularly after bronchopneumonia and bronchial ob truction due to tumor or aspirated foreign bodies It is generally believed that mechanical factors alone do not produce bronchiectasis An inflammatory process with necro i of the wall of the bronchi may produce bronchiecta is without other external forces entering into the picture Bronchial ob truction and atelecta is are important factors particularly since the associated impairment of drainage provide conditions which favor the development of local infection Bronchiecta is occur frequently in association with chronic bronchitis a thma generalized emphysema chronic sinusiti mea les and other exanthematou di ea e and whooping cough



Fi 49 —Bron hie tasi with Asso iated Emphysema and Patches of Atelectasi

There is diffu e irregular m ttl d den ity throughout both lung field Within thi density there are numerou small rounded areas of radiance which are con istent with bronchie tati f rmations The invol ement of the apices and upper lung fields ra the pos ibility f tuber ul is There is marked emphysema bilaterally manifested by depre ion and flatt ning of th di phragm increased radiability throughout both lun field and wid n ng f the int r p ce The hilus shado s are increased in width and density and are rregular in utline There are horizontal curvilinear bands of density at the ba e in the region imm diately abo e th diaphragm due to fibrosis atelecta is and chronic pneumonitis (white arrow

Bronchiectasi i a destructive and reparative process which affects the lung parenchyma and the bronchial wall Interstitial infiltrations fibrosis pleurit atelecta is and emphysema u ually occur in as ociation with bronchiectasis The proce s may be localized or diffuse and bilateral The affected portion of the lung may be shrunken by fibrosis even though the bronchi are widely patent

In the early stages the changes in the bronchial walls are inflammatory and destructive in the later stages principally reparative The bronchial walls are thickened and distorted due to fibrosis of the wall The bronchi are dilated The dilatation may be slight or several times the normal in width Cylindrical saccular and cystic dilatation may occur in varying proportions in different parts of the lung The process involves the basal portion of the lung particularly The right middle lobe and the lingular portion of the left upper lobe are common sites of involvement while the superior segments of the lower or upper lobes are seldom involved Bronchiectasis may involve the apices of the upper lobes with or without tuberculosis There is necrosis of the muscularis fibrous tissue replacement of the muscle layers and extensive degeneration of the bronchial epithelium

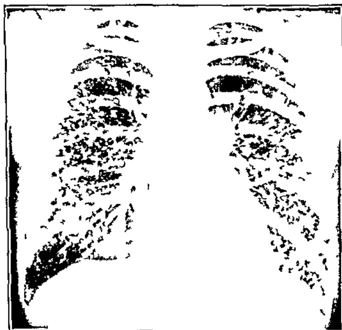


Fig 50 —Normal Bronchogram

The bronchi leading to the individual lobes are clearly outlined bilaterally The walls of the bronchi are coated with the opaque material resulting in better delineation than when the bronchi are completely filled The fine granular appearance in the peripheral portion of the lung fields and at the left base is due to extension of the opaque medium into the alveoli

The bronchi are lined by granulation tissue with partial or complete destruction of the ciliated epithelium The bronchial wall may be destroyed with the formation of cavities in the lung Cylindrical dilatations occur in less severe forms of the disease saccular or cystic types of bronchiectasis being associated with more advanced destruction Exudate in the lumen of the bronchi may be primary or more commonly due to secondary invaders

Bronchiectasis has five important clinical and anatomic features First It is rarely a diffuse disease of the bronchial tree characteristically involving a group

[illegible] bronchi such as those in a single lobe or a portion of the lobe and may be limited entirely to this area. The affected segments may be adjacent or are multiple. The bronchi in the uninvolved areas are frequently normal. Second: Bronchiectasis is frequently not a progressive disease; many cases show well developed involvement of a single segment which persists for many years without extension to other portions of the lung. If an attack of pneumonia takes place, however, other segments may become involved. Third: Bronchiectasis is rarely seen as an isolated finding in an otherwise normal lobe, there being usually various other abnormalities in the surrounding pulmonary tissue. These associated changes comprise atelectasis, fibrosis, organized pneumonitis, local emphysema and in some instances advanced destruction of the

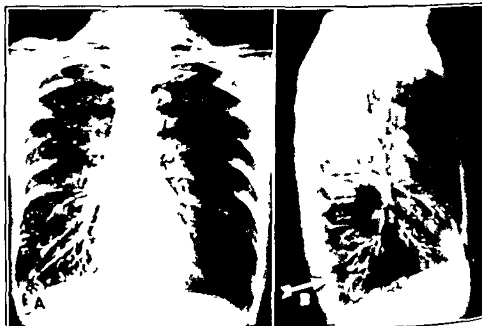


Fig. [illegible]. Bronchiectasis of the Right Middle and Lower Lobes. Bronchographs.

A, Posteroanterior projection. There is cylindrical and saccular bronchiectasis at the right base. The right lung is definitely smaller than the left and there is emphysema on the left. The heart is displaced slightly to the right.

B, Lateral projection. There is extensive bronchiectasis at the right base involving the lower lobe (white arrow) and the middle lobe (black arrow). The middle lobe lies anterior and is seen through the overlying heart shadow. The opaque material clearly outlines the trachea, the major bronchi and the bronchioles.

alveolar tissues. Fourth: Bronchiectasis is characteristically a disease of youth although it may develop at any age. Most patients with bronchiectasis have a chronic productive cough with abundant purulent sputum. It was formerly believed that the chronic cough had a dilating effect on the bronchi. However, during cough the pressure is greater in the alveoli than in the bronchi which tends to compress the bronchi rather than cause dilatation. If the disease was due to chronic bronchitis it would be seen in the older age group as is the case with emphysema. There is no definite association between the severity of chronic

inflammation and the degree of bronchial dilatation Fifth Congenital abnormalities are very common in the congenital cystic type of bronchiectasis

There are five factors which may be important in the development of bronchiectasis 1) direct bronchial infection 2) congenital malformations of the bronchial tree 3) bronchial stenosis 4) pulmonary atelectasis and 5) pneumonitis

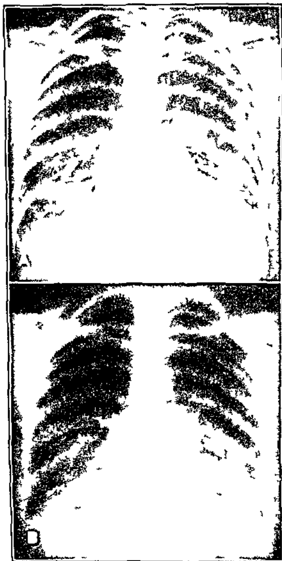


Fig 52 —Bronchiectasis Saccular Type Bronchogram

There is extensive saccular bronchiectasis bilaterally The process is most marked at the left base

A Routine Bronchogram The extent of the process is not well shown

B An overexposed film with the Bucky diaphragm The localization extent and character of the process in the retrocardiac area are clearly demonstrated

and its sequel pulmonary fibrosis. No one of these five can explain all cases. Acquired bronchiectasis is a disease of the pulmonary parenchyma as well as the bronchial tree itself. *In every case there is a definite reduction in the number of aerated alveoli.* The lack of aerated alveoli distal to the involved bronchi renders cough ineffective as a mechanism for clearing the bronchial secretion and there is stagnation of secretions in the dependent bronchi. Bronchial infection may cause atelectasis by *the mucopurulent secretions obstructing the bronchioles* and interfering with the aeration of the alveoli. Children are especially apt to develop this type of obstructive atelectasis. Atelectasis is most apt to develop in the lower or middle lobes and in the lingula of the left upper lobe

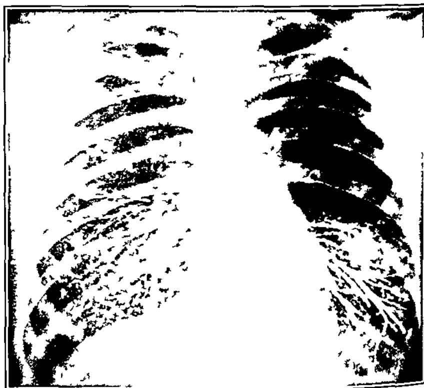


Fig. 5.—Cylindrical Bronchiectasis. Bronchography.
There is marked dilatation and clubbing of the bronchioles of the left lower lobe: cylindrical bronchiectasis.

and these are the areas in which bronchiectasis is most common. It is extremely important in the prevention of bronchiectasis to prevent or alleviate all causes of atelectasis. Of the five factors, congenital cystic disease and bronchostenosis are uncommon. Therefore the other factors, chronic bronchial infection, pulmonary atelectasis and pneumonitis or its sequel pulmonary fibrosis are the important factors in the causation of bronchiectasis.

Clinical Manifestations. The most important symptom of chronic bronchiectasis is productive cough. The sputum may be copious and fetid odor is frequently present. The patient has a foul taste in the mouth. The amount of sputum and the frequency of the cough are affected by posture and change in

position It is therefore usual for the patient to have paroxysms of cough on arising in the morning Hemoptysis is common and in consequence the condition is easily confused with tuberculosis Profuse pulmonary hemorrhage may occur Chest pain is the result of pleurisy or empyema which complicates the underlying bronchiectasis particularly after an attack of pneumonia Despite the long standing character of the disease the patients remain in good nutrition and normal vigor for many years In some instances there is easy fatigability gradual weight loss weakness and emaciation Fever is seldom present Dyspnea and cyanosis occur late in the disease and are due to pulmonary fibrosis and emphy

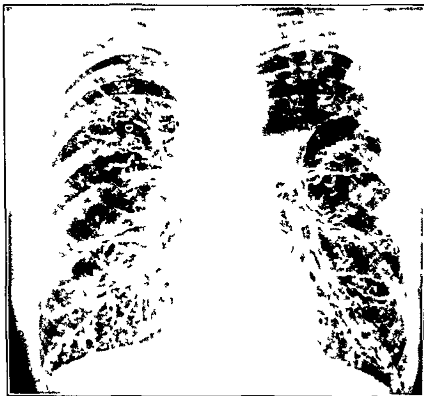


Fig 54 —Bilateral Bronchiectasis Bronchography

There is advanced cystic bronchiectasis with widespread involvement bilaterally Simultaneous filling of all the lobes reveals the widespread extent of the disease

sema Cor pulmonale and right ventricular heart failure frequently develop in the advanced stages of the disease Frequent attacks of pneumonia commonly supervene and may lead to abscess formation The physical signs are variable and inconstant In many instances there are no clinical manifestations on physical examination Rales may be present over the involved segment of the lung The rales are inconstant and not characteristic Atelectasis emphysema abscess and other concomitants of the disease modify the clinical manifestations and may obscure the underlying bronchiectasis

Roentgen Manifestations (Figs 47–53) —There occur many instances of long standing and well established chronic bronchiectasis in which the plain roentgenograms reveal slight or no demonstrable abnormalities Stress is laid on this point because the clinical diagnosis of bronchiectasis is more definite and may be made earlier than the roentgen diagnosis if reliance is placed on roentgenography without the use of opaque media The changes which may be demonstrable on the plain roentgenograms are the following (Fig 47) 1) Generalized prominence of the bronchovascular markings particularly in the parahilar and basal regions these markings extend well out to the periphery and often to the apices 2) Within the areas of peribronchial thickening there may be *scattered irregularly multiple small rounded areas of increased radiance with*



Fi — Iodized Oil in the Lungs after Bronchography

After bronchography the opaque material may be retained in the lungs for long period The roentgen picture is that of diffuse haziness with granular mottling The changes are characteristic and are easily recognized by the experienced observer To the novice the appearance may be very confusing and an erroneous diagnosis of pulmonary fibrosis, metastatic disease or other abnormality is frequently made

thin sharply defined walls These areas vary in size from 2 to 5 mm in diameter and are most numerous at the bases but may occur in any portion of the lung even the apex *They are usually bilateral and somewhat symmetrical in distribution* imparting a honeycomb appearance to the lung 3) Patchy areas of increased density especially in the lower lung field due to fibrosis atelectasis and chronic pneumonitis (Figs 48–49) 4) Small cavities of different size with or without fluid levels 5) Irregularity tenting fixation and flattening of the diaphragms due to pleuritic adhesions 6) Varying degrees of emphysema either bilateral and generalized or localized due to compensatory changes 7) Dense rounded or fusiform areas of increased density usually at the bases

and parallel to the bronchial tree These are due to retained secretions in the dilated bronchi and bronchioles 8) A dense triangular shadow at the base near the heart border on the right is a common occurrence and is usually caused by partial atelectasis of the right lower or middle lobe A similar appearance at the left base may be obscured by the overlying heart shadow and is demonstrable in lateral projections or sagittal films made with the Bucky diaphragm

The use of iodized oil is essential for the proper delineation of the areas involved in bronchiectasis and the determination of whether the lesions are of the cylindrical saccular or bullous type The technic of injection is not difficult Roentgenoscopic control is invaluable Each lobe may be filled in turn and complete visualization is usually possible In the cylindrical type of bronchiectasis the bronchioles in the affected portion of the lung are dilated and do not decrease progressively in size (Fig 53) The saccular variety shows grape like collections of dilated rounded areas in the region of the bronchioles (Fig 52) The bullous form presents numerous club like dilatations The extent location and type of involvement are demonstrated by the use of sagittal oblique and lateral roentgenograms Each lung should be observed separately as simultaneous filling of both lungs often obscures important details The retrocardiac areas subdiaphragmatic extensions of the lungs and the lingular branch of the left upper lobe bronchus must be studied in particular detail Patches of atelectasis or secretion filled bronchi may be diagnosed by non visualization of the involved segment Foreign bodies or other lesions may be demonstrated in cases of long standing bronchiectasis and should be carefully sought for in every instance Neoplasm of the lung must be considered in all cases of localized bronchiectasis With asthma dilatation of the bronchi occurs but this is not truly bronchiectasis in the clinical sense of the term

Cystic Bronchiectasis —Cystic bronchiectasis occupies a border line position between cystic disease of the lungs and saccular bronchiectasis Roentgen examination shows a honeycomb or sponge like appearance in the involved portion of the lung due to a cluster of thin walled closely packed cavities separated by fine trabeculation (Fig 54) The cavitations are usually round ovoid or irregular in outline due to overlapping in various planes The size of the cavities varies from that of a pea to a walnut Small fluid levels are frequently present There is marked fibrosis or shrinking of the lungs in some instances although these manifestations are more frequently absent There is no displacement of the heart or narrowing of the interspaces The honeycomb or sponge like appearance of cystic bronchiectasis is usually pathognomonic particularly after injection of iodized oil The differentiation from tuberculous cavities rests on the typical spongy structure the multilocular thin walled character of the annular formations and the absence of other changes indicating an infiltrative process The large or so called giant emphysematous bullæ resemble more closely the balloon type of pulmonary cyst In cystic bronchiectasis the cavities are usually small and do not form sharply outlined ring shadows There are multiple fluid levels in cystic bronchiectasis and these do not occur as a rule in the emphysematous blebs Other forms of cystic disease of the lungs especially the large solitary or multiple cysts occur in infants and young children whereas cystic bronchiectasis occurs in the older age groups The large bleb types may be associated with symptoms of respiratory distress and mediastinal pressure often giving clinical signs which closely simulate pneumothorax The differentia

tion between bronchiectasis and lung abscess is made by the fact that in the former the lesions are multiple, widely scattered, and lie in close relation to the bronchioles, while lung abscess is usually single and larger in size.

Bronchiectasis is primarily a disease of the lower lobes. However, the upper and middle lobes may also be affected. The lingular division of the left upper lobe and the right middle lobe are frequently involved. It must be borne in mind that bronchiectasis may be secondary to bronchiogenic carcinoma, lung abscess, and pulmonary tuberculosis and an etiologic diagnosis is always important. Retained secretions may partially block a bronchus and prevent filling of the areas. Therefore, if the entire bronchus is not well visualized, re-examination must be carried out after drainage. Similarly, in the study of lung abscess the bronchus leading to the abscess may be blocked and the abscess not visualized. The longer the duration of the abscess, the greater the likelihood of development of bronchiectasis. The simultaneous presence of bronchiectasis and lung abscess can be recognized only when iodized oil studies are used. In cystic disease of the lung a cyst may become infected and simulate a lung abscess. The presence of multiple trabeculæ in the peripheral portions of the cyst may be of value in diagnosis. Care must be exercised not to flood the alveoli with an excess of oil as the resultant drowned lung appearance may give an appearance closely simulating cavity. In the presence of tumors, bronchography shows the presence of a block but does not always indicate the nature of the underlying pathology. The chief value of bronchography in this case is to indicate which bronchus should be most thoroughly explored.

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PULMONARY DISEASES CAUSED BY FUNGI AND HIGHER BACTERIA

Introduction—The fungi and higher bacteria which are the most frequent causes of diseases of the lungs and pleura are divided into four main groups 1) the yeast like fungi the etiologic factors in moniliasis blastomycosis sporotrichosis leptotrichosis and streptothricosis 2) the molds or mold like fungi The most common example in this group is aspergillosis 3) the actinomycoses and the coccidioidomycoses the higher forms and 4) syphilis Diseases caused by the fungi are becoming increasingly common and the presence of this type of lesion must be suspected in dealing with pneumonias which do not respond to specific therapy long standing chronic non tuberculous pulmonary disease not due to tuberculosis and bizarre or unusual conditions which do not fall into the common classifications The occupational history is important as these conditions are apt to occur in individuals who work with wool hair skin and other parts of the bodies of animals Travel in foreign countries particularly in the tropics is a frequent source of origin of the fungus diseases

The clinical manifestations are variable inconstant and atypical Frequently there is a generalized process with involvement of the cutaneous subcutaneous mucous osseous and visceral organs The lungs may be involved directly through the inhalation of the spores particularly in blastomycosis and coccidioidomycosis In some instances the pulmonary manifestations are those of an acute pneumonic process More commonly however the disease is low grade chronic and persists for months or years with remissions and exacerbations Draining sinuses in the neck chest or other parts of the body should call attention to the possibility of these diseases The fungi may occur in association with other chronic pulmonary diseases acting as a complicating factor The demonstration of the fungi in the sputum is essential for diagnosis However it must be remembered that the fungi may be secondary invaders associated with other chronic pulmonary disease The suspected material is examined after treatment with a solution of 10 per cent sodium hydroxide Sabouraud s medium and blood agar plates are used for the cultures Study of the tissues or the discharge from a draining sinus is important Specific agglutination tests and animal inoculations are utilized to establish the diagnosis The absence of tubercle bacilli is important The presence of an elevated eosinophilic count in the blood is helpful

Fungus or Yeast Infections (Sporotrichosis Leptotrichosis Moniliasis Blastomycosis)—The various yeast or fungus diseases may cause closely similar findings on the roentgenogram and it is usually not possible to differentiate the individual types by roentgen methods alone The acute forms are characterized by a suppurative bronchopneumonia The chronic varieties are diffuse non specific and granulomatous in nature and closely resemble tuberculosis The bronchi contain purulent exudate The hilar lymph nodes are enlarged Multiple nodular

formations and abscesses are common The lung between the area of abscess formation usually shows bronchopneumonic consolidation The pleura is involved and there is a tendency to the development of fistulous communications from the bronchi and pleura to the chest wall Fluid is not common but does occur The lesions tend to involve the mid zone and the basal portions of the lungs although any portion or all of the lung may be affected The picture is that of a chronic pneumonitis or lung abscess and closely simulates metastatic neoplasm tuberculosis and pneumoconiosis In the less common localized form there is a single sharply defined area of density or multiple scattered, small areas of varying size which easily may be confused with neoplastic disease Localized abscesses fluid in the pleural cavity and diffuse thickening of the pleura may supervene

Toxoplasmosis and Brucellosis —Toxoplasmosis is due to a yeast like parasite and is seen particularly in mammals and birds The roentgen manifestations comprise a diffuse interstitial pneumonitis which closely simulates the changes in primary atypical or virus pneumonia Brucellosis is more commonly known as Malta fever or undulant fever The pulmonary manifestations may be acute or chronic The acute forms are characterized by pneumonic densities In the chronic form the manifestations are similar to those which occur in the other yeast or fungus infection

Blastomycosis —Blastomycosis is an infection due to a yeast like fungus and is characterized by the formation of suppurative and granulomatous lesions in various parts of the body with a particularly high incidence in the skin lungs and bones The disease is not contagious although in some cases the infection may be acquired by direct inoculation or prolonged physical contact with an infected individual It is most commonly seen between the ages of 20 to 40 years is much more frequent in males than in females and is more common among the poorer classes All races are equally susceptible The systemic forms are most apt to affect the respiratory tract The lesions may be disseminated throughout the body and involve the skin subcutaneous tissues and bones as well as the lungs The course is usually insidious and the infection in most instances becomes far advanced before the diagnosis is suspected The onset is as a rule that of an acute or subacute respiratory infection with dry hacking cough pain in the chest low grade fever and some dyspnea After a few weeks or months the sputum is purulent may be blood streaked and tends to increase in amount The dyspnea and fever become more marked and there is loss of weight and strength with night sweats Pleural involvement is less common than in actinomycosis The mediastinum is practically always involved and the pericardium and the heart may be invaded The physical signs of pulmonary blastomycosis are those of pulmonary abscess or massive tuberculous infection There is dullness and the breath sound is changed Rales are seldom present and are variable Discharging sinuses or subcutaneous abscesses over the thorax or other parts of the body are common

Roentgen Findings —In some cases the early parenchymal lesions are minimal and consist mainly of an enlargement of the mediastinal nodes In others there are dense masses with irregular borders projecting from the hilum and the picture very closely resembles that seen in actinomycosis and neoplasm of the lung The latter diagnosis will usually be favored if the patient complains of pain in the chest and hemoptysis Associated destructive lesions commonly occur in the ribs and are also thought to be manifestations of inoperable carcinoma In

the early stages the lesions may be unilateral Bilateral involvement develops in most cases with dense shadows in the lung fields Small cavities may be present and the cavitations usually have irregular hazy borders Spread of the infection through the blood may produce miliary pulmonary lesions The miliary lesions in the lungs are denser coarser and slightly less well defined than in miliary tuberculosis Studies of the spine and ribs show destructive changes with a tendency to proliferation in some cases The bodies of the vertebræ may be destroyed much as in tuberculosis or metastatic carcinoma Potassium iodide was suggested by Gilchrist in the treatment of this disease and the oral administration of this drug results in temporary improvement in some instances and cure in others However in others there apparently occurs spreading of the disease after the administration of the drug Roentgen therapy and vaccines may be helpful

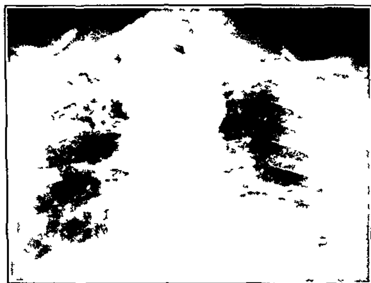


Fig 56 — Moniliasis

There is irregular mottled density involving the right apex and infraclavicular region and the lower third of the left lung field The process in the right upper lung field is very similar to that seen in tuberculosis Monilia were recovered from the sputum There was no evidence of tuberculosis on clinical examination and no tubercle bacilli were present in the sputum

Moniliasis (Fig 56) — The fungus which is the cause of moniliasis is isolated from the stools vagina skin and throat of apparently healthy individuals in so many instances that a diagnosis of the disease is difficult to establish The organism is also frequently found in the sputum of patients with tuberculosis lung abscess and other pulmonary conditions Therefore a diagnosis of moniliasis is warranted only if the fungi are found constantly on repeated examinations and other etiologic agents are not present The disease is an acute or subacute infection which may involve the mouth vagina skin nails bronchi or lungs Rarely it produces septicemia endocarditis or meningitis The disease occurs at all

ages in all races and in both sexes Oral thrush occurs most frequently in infants and elderly people with wasting diseases such as tuberculosis and cancer Bronchial moniliasis is not uncommon The clinical picture is extremely varied. Cough is the most characteristic and distressing symptom However the health of the patient is not affected seriously as a rule The sputum is colorless mucoid and gelatinous The disease may disappear spontaneously In other instances it persists for years with periodic progressions and retrogressions The physical findings are those of bronchitis with medium and coarse rales at the bases of the lungs The roentgen study in the bronchial form shows only a non specific type of peribronchial thickening In some instances a peculiar hazy type of linear fibrosis may occur In the pulmonary form of the disease the symptoms are more marked The temperature and pulse are moderately elevated pleural pain is common and effusion occurs occasionally There is a harassing cough and the patient produces mucoid gelatinous sputum which is occasionally blood streaked Purulent sputum indicates that secondary infection has occurred. In the broncho pneumonic type there are lesions in one or more lobes Medium moist rales are present in the involved area In severe cases the physical findings are those of confluent or lobar pneumonia with dullness increased tactile fremitus and medium moist rales Many cases heal spontaneously In others recovery is not complete and the patient develops a chronic bronchial infection Death may occur if two or more lobes are involved The roentgen picture is very variable The findings are usually similar to those in broncho-pneumonia except that the margins of the lesions are less sharply defined Two or more lobes are frequently involved and the apices are usually unaffected The lesions are labile and films made at intervals of days or weeks show definite evidence of clearing in some areas with new foci and spreading in others In severe infections the massive lesions are dense and smooth and may involve an entire lobe If more than one lobe is involved some of the lobes may show almost complete consolidation while others contain only broncho pneumonic patches

Actinomycosis —(Lumpy jaw Streptothricosis Nocardiosis) The actinomycoses are closely related to the bacteria more so than any of the other f[ungi] Infection with actinomycosis causes a chronic disease which is characterized by the formation of granulomatous lesions which tend to break down with the formation of abscesses which discharge through multiple draining sinuses The disease is the commonest of the systemic mycoses and is of world wide occurrence Actinomycosis has been found in patients of all ages from early infancy to the seventh and eighth decade of life The disease is rare in children under 10 most cases occurring between the ages of 15 and 35 Males are affected approximately twice as frequently as females The disease is more common [in] agricultural workers

Symptomatology — In a series of 1 330 cases collected by Cope 56 8 per cent began in the neck 22 3 per cent in the abdomen 15 per cent in the thorax and 5 9 per cent in other parts of the body The primary infection in the lung re[sults] from aspiration of infective material from the mouth The aerobic actinomyces may be inhaled with dust straw or other foreign material The symptoms [of] the first few weeks of the disease are those of a low grade chronic pulmonary infection with mild fever cough and expectoration Abscesses develop in the lungs The sputum becomes mucopurulent and may contain small quantities of blood Chest pain is common and pleural effusions develop frequently Th[e]

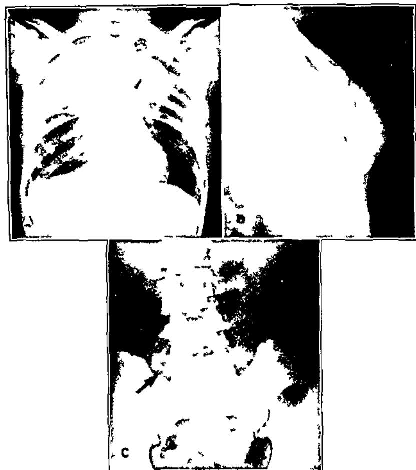


FIG 57 —Actinomycosis

A Sagittal Roentgenogram of the Chest There is a rounded sharply defined area of incr a ed density in the paravertebral portion of the left upper and m l lung field On the right s de there i diffusely diminished radiance with strand like areas of increased density in the infraclavicular region

B Lateral Proje tion There i a large roun led soft tis ue m ss projecting from the anterior chest wall The margin of this area are mooth and harply defined The mass was d e to a large actinomycoti ab ce s The r unded density in the left upper lung field in the roentgenogram of the che t i cau ed by this tissue mass and is not due to pulmonary in ol ement The disease in ol ed the right upper and mid lungs and had extended through the pleura nd chest all to form a l rge absc ss

C Sagittal Vie of the Lumbos c al Spine There is extensi e destruction of the lamina and the ped cle of the fourth and fifth lumbar vertebræ on the right and of the right fifth transv r process The intervertebral space betw en the fourth and fifth lumbar vertebræ s narrow ed nd irregul r (black arro) The change re due to in olv ment of the spine by th act nomy otic proce s

abscesses extend directly through the chest wall producing numerous draining sinuses There is marked loss of weight and strength anemia spiking of temperature night sweats dyspnea and other signs of a severe chronic pulmonary disease The infection may extend to the pericardium the mediastinum and the heart The signs are those of tuberculosis and closely resemble this disease except that the onset is more commonly at the bases of the lungs rather than in the upper lung fields The co existence of abscesses or draining sinuses should suggest the diagnosis

Roentgen Findings (Fig 57) – The roentgen changes in pulmonary actinomycosis are variable The lesions are widespread and abscess formations are prominent The process extends directly from the lungs through the pleura destroys one or more ribs and may become widespread The mediastinal lymph nodes are greatly enlarged There is marked pleural thickening with narrowing of the interspaces the changes closely simulating atelectasis except that there is no displacement of the heart and trachea In the lungs the process may appear consolidative or infiltrative with irregular poorly defined margins The involvement may be parahilar peripheral or basal The consolidation may be smooth and massive often containing multiple small poorly defined areas of increased radiance and abscess formations The lower portions of the lung fields are more commonly affected than the apices and infraclavicular regions However a single lobe may be involved Areas of marked density with irregular margins may extend from the hilum into the middle and peripheral portions of the lung closely simulating the picture in primary or metastatic carcinoma of the lung While most frequently bilateral unilateral lesions also occur As the process advances extension to the sternum and spine takes place with extensive destruction of these structures The periosteum of the ribs may be elevated and on Bucky films there is extensive periosteal proliferation closely simulating primary osteomyelitis Strictures of the esophagus trachea and bronchi have been recorded Involvement of the pleura results in pleural effusion or massive pleural adhesions The fluid may be free or encapsulated

Geotrichosis – Geotrichosis is an infection due to geotrichum a fungus which produces lesions in the mouth intestinal tract bronchi and lungs The disease is easily confused with blastomycosis especially if the diagnosis is made on direct smear culture studies being essential for differentiation As with moniliasis the fungus is endogenous and is frequently found in the mouth and intestinal tract of normal individuals The bronchial form is characterized by a chronic tracheobronchitis with cough and expectoration of a mucoid or gelatinous type of sputum which may be blood streaked There are rales at the bases There is little if any elevation of temperature or pulse The general health of the patient remains good although the cough may be very troublesome Pulmonary geotrichosis closely simulates tuberculosis because of elevation of temperature pulse and respiration The sputum is mucopurulent white in color and not greenish as in tuberculosis Hemoptysis is of frequent occurrence On physical examination there may be dullness altered breath sounds and fine rales The picture is similar to that of acute pulmonary tuberculosis However the white count is elevated in geotrichosis The finding of the organism in the sputum establishes the diagnosis The geotrichum may occur in the sputum in association with Friedlander s bacillus and may be a secondary invader

tuberculosis In some cases it is difficult if not impossible to determine accurately which is the primary factor

Roentgen studies of the chest in the bronchial form of the disease show diffuse peribronchial thickening with in some instances fine mottling in the mid lung fields or at the bases The pulmonary form of the disease shows smooth dense patches of infiltration with or without the presence of thin walled cavities The lesions may occur in any portion of the lung but are more commonly in the upper lung field



Fig 58 —Geotrichosis

There is a solitary cavitation in the axillary portion of the right lower lung field (white arrow) a characteristic manifestation of geotrichosis

Coccidioidomycosis —Coccidioidomycosis is the most infectious of the systemic mycoses and is caused by the inhalation of coccidioides immitis The disease is endemic in the San Joaquin Valley of Southern California and the majority of those who live in this region for any length of time eventually acquire the infection It also occurs in Texas Arizona New Mexico and other areas and because of the speed of modern travel and the redistribution of people during World War II cases may be encountered anywhere The disease is not transmissible from man to man It is also known by the names of valley fever desert rheumatism and San Joaquin fever The infection is usually acquired by contact with the soil or the inhalation of contaminated dust the fungus being introduced into the skin following an injury or breathed into the lungs The condition has also been found in cattle sheep and dog However it appears unlikely that man acquires the infection from animals Although it has been

seen in individuals from the age of three months to over 70 years of age; it is most prevalent in persons 25 to 55 years old. Males are commonly affected more than females, and the dark skinned races apparently have a higher susceptibility. Laborers and laboratory workers have developed the infection following accidental inhalation of material from old dry cultures of the organism.

The disease occurs in two forms. The primary type is usually acute, benign and self limited. The progressive variety is chronic, malignant and widely disseminated throughout the body with involvement of the skin, subcutaneous tissue, viscera and bones. The clinical picture in the acute primary stage is that of a mild upper respiratory infection. There is an incubation period of 10 to 14 days subsequent to the inhalation. The temperature is 99–101°F. There is backache, headache and upper respiratory symptoms or bronchopneumonia with cough. The cough may be slight and non productive or accompanied by mucopurulent and blood streaked sputum. Pleurisy with effusion may mark the onset. In others there is a dry pleurisy with pain in the chest on respiration and a constriction across the upper chest. Rarely the initial complaints may consist of severe continuous or intermittent chest and precordial pain closely simulating coronary occlusion, fracture of the rib or renal colic. There are transient skin lesions closely resembling erythema nodosum or erythema multiforme. In some cases there is a rapidly fulminating course characterized by extensive pulmonary and glandular involvement, meningitis and fatal termination. Most commonly the initial symptoms subside in one or two weeks and recovery takes place. After an interval of several weeks the fever may reappear and the remissions are usually characterized by the development of skin lesions. In the chronic type the disease runs a protracted course with exacerbations and remissions. The clinical picture closely resembles tuberculosis, blastomycosis and malignant lymphoma.

The patients who develop the malignant forms of the disease show dissemination within a few weeks or months throughout the body. Periods of improvement may be succeeded by recurrences. The progressive forms result in prolonged invalidism or terminate fatally in a few months. There is low grade fever, anorexia, weakness and marked weight loss with dyspnea and cyanosis. The sputum is mucopurulent or bloody and contains many fungi. Physical examination reveals variable and inconstant findings. The bones, skin, subcutaneous tissues, internal organs, brain and meninges are invaded. Miliary dissemination results in death in a few weeks.

Roentgen Findings.—Approximately 80 per cent of the patients reveal pulmonary changes on roentgen study. The roentgen manifestations are protean and tend to fall into several patterns although various combinations may co-exist at different times. There may be slight irregular density in the hila and parahilar regions as in any acute pulmonary infection. More commonly there occurs extensive confluent consolidation of the bronchopneumonic or lobar type extending from the hilus into the middle and lower lung fields. The densities are hazy and mottled or homogeneous and may clear in one or two weeks or persist for many months. Atelectasis does not occur. Pleural effusions, small or large in amount, usually absorb rapidly and completely although rarely the fluid persists for long periods. Tuberculosis or bronchiogenic carcinoma may be closely simulated by these findings.

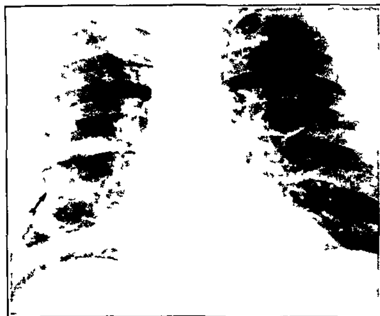


Fig 59 —Coccidioidomycosis

There is a ring like area of increased radiance n the right lung field at the level of the seventh interspace posteriorly (black arrow) a avitation The patient had been in the San Joaquin Valley t o years previou ly while in the Armed Forces

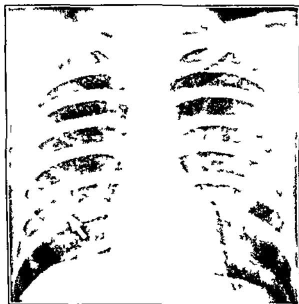


Fig 60 —Coccid oidomycos s

Th r is an annular a ea of increased radiance n the r ght lo er lung field at the level of the fourth and fifth interspaces anter orly a characteristi man festation of coccidi idomycosi

Peribronchial infiltrations occur with thickening and confluence of the parenchymal markings, stippling and mottling. While most often seen in the parahilar and basal regions, involvement of the apex and upper third of the lung results in a picture much like that of tuberculosis. Hilar and mediastinal adenopathy is marked and involves the tracheobronchial and bronchopulmonary glands. The adjacent lung tissue may or may not show mottling and the findings closely simulate childhood tuberculosis.

A typical manifestation in many instances is a well circumscribed nodular lesion in the parenchyma of the lung. The nodules are 2 to 3 cm in diameter, occur most frequently in the middle and lower lung field and are usually single but may be multiple. The density may be slight or marked. There may be mottling and haziness in the adjacent lung. The masses enlarge slowly and after an interval of months resolve or develop into thin walled cyst like cavities or ring shadows (Figs 59, 60). These cavitations in some instances persist for months and years, enlarging and regressing even though the patient is asymptomatic; in others they shrink into very small nodules which in some instances calcify. The differential diagnosis during the nodular cavitation stages must include tuberculosis, lung abscess, carcinoma, cyst and emphysematous blebs.

The diagnosis of coccidioidomycosis may be difficult as the roentgen manifestations are variable and closely simulate many other diseases. Positive skin tests with the antigen of coccidioides immitis are of great value. Biopsy from the skin lesions may be necessary in doubtful cases. Swygert et al found that the pulmonary changes in their series of cases were distributed as follows: Pneumonitis 70 per cent, adenitis 23.5 per cent, cavitation 7.8 per cent, nodules 5.2 per cent, pleural effusion 2.6 per cent, no lung findings 2.6 per cent. All persons who have been in regions where coccidioidomycosis is endemic should have repeated roentgen studies, especially in the presence of skin lesions. The findings of cavities, ring like shadows, or other changes which have been described above indicate the presence of coccidioidomycosis. The disease is particularly virulent in the colored race. Tuberculosis may coexist with coccidioidomycosis and the possibility of the two diseases occurring together must be borne in mind.

Syphilis.—Syphilis occurs in the lungs in various forms. In congenital lues there is a diffuse consolidation which produces an area of density very similar to that seen in other forms of pneumonia or scattered nodular densities much like those occurring in metastatic neoplasm, tuberculosis and bronchopneumonia. The adult types result in the formation of gummas or diffuse pulmonary fibrosis. The gumma is usually a dense, sharply circumscribed, rounded area of varying size which may be found in any portion of the lung. There is little if any change in the size or shape of the mass on serial roentgenograms which forms an important aid in differentiating the lesion from primary or metastatic pulmonary neoplasm. In fibrosis of the lung there is diffusely diminished radiance over the affected portion of the pulmonic field, retraction of the mediastinal contents, elevation of the diaphragm, narrowing of the interspaces and compensatory emphysema of the unaffected lung. Hernia of the mediastinum may occur. However, all of the above described changes are also present after chronic pulmonary abscess, bronchostenosis from any cause, unresolved pneumonia and a wide variety of other conditions comprising the manifestations of a nonspecific fibrosis of the lung. The fibrotic changes therefore cannot be considered characteristic of lues as they may occur in association with many other diseases as well as in syphilis.

With modern methods of therapy syphilis is becoming less frequent and the late manifestations of the disease are seen only rarely No proven case of gumma or syphilitic fibrosis of the lung has been encountered in the Roentgen Clinic of the Boston City Hospital in recent years

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TUBERCULOSIS—HISTOPLASMOSIS

TUBERCULOSIS

Introduction.—One of the great advances in modern medicine has been the advent of mass radiography of the chest for the detection of tuberculosis and other pulmonary lesions. While the techniques differ in various clinics, some using photofluorographic apparatus with miniature films and others full size roentgen films and roentgenoscopy, the method is now very extensively utilized and has proven of inestimable value in determining which individuals do or do not have pulmonary disease. Roentgen study detects the tuberculous process in many unsuspected cases, serves to demonstrate its extent, location and type, and affords an accurate method of observing the progress of the disease and the effects of therapeutic measures. Absence of roentgen changes in a patient with complaints and clinical findings suggesting tuberculosis is now accepted as practically definitely excluding the disease. It is generally agreed that roentgen examination is more dependable than clinical observations. The question of the activity of a lesion may be determined by the clinician better than by the roentgenologist as it is often impossible to determine from a single roentgen study



Fig. 61.—Primary Tuberculosis.

There is a rounded mass at the left lung root. In infancy and childhood tuberculosis is commonly localized to the parahilar regions with involvement of the hilum glands.

whether the process is active or not repeated examinations at intervals of weeks or months being required to determine this point

Roentgenoscopic observations alone are not a satisfactory method of study and cannot be relied on. Early lesions may be overlooked. Comparisons to observe the progress of the case cannot be made with any degree of accuracy even if the examinations have been made by the same observer. The personal equation becomes too important a factor in the observation and evaluation of the findings. There is a definite element of danger in the amount of exposure the roentgenologist would receive in carrying out studies in large numbers of patients.

Classification —Tuberculosis is commonly classified as 1) primary and 2) secondary. The primary form is the initial infection which is usually seen in children. The secondary type is referred to as the adult type and represents the stage of reinfection.

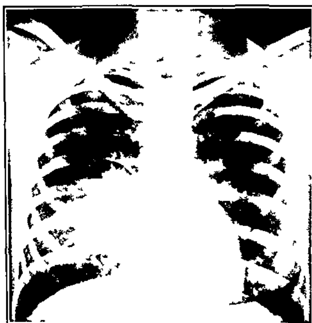


FIG 67 —Parahilar Tuberculosis

There is an irregular area of increased density in the parahilar portion of the right lung field. The margins of the area are poorly defined and irregular in outline. There is extensive mottling in the adjacent lung.

I Childhood Tuberculosis —*A) Primary Tuberculosis* (Figs 61 67) —Tuberculosis in infancy and childhood begins as an irregular area of density which may be mottled or uniform and either small or large. The process is usually triangular in shape with its base in the subpleural portion of the lung. The hilus glands are enlarged in some cases very markedly so. This is termed the primary complex and is characterized by increased width of the mediastinal or hilus shadow usually with lobulation. As the process progresses the density in the lungs increases and cavitations often develop. In some instances the

process is localized mainly or entirely in the hilum glands for considerable period, extension to the lungs developing only later Cases which progress favorab show a slow progressive decrease in the pulmonary changes and the size of the glands Resolution requires a much longer time than pneumonia as the caseation absorbs and fibrosis develops very slowly An initial lesion of 4 or more cm in extent may decrease to approximately 1 cm in diameter in a period of several months After the lapse of months or years calcification supervenes and th

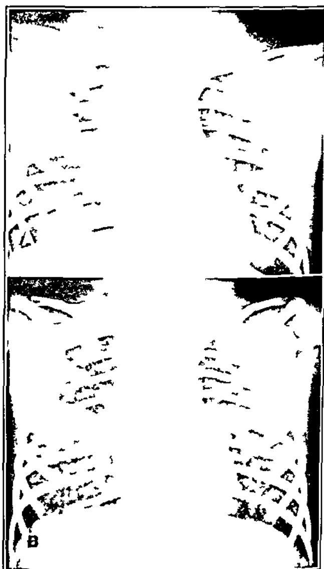


Fig 63 —Miliary Tuberculosis

A The supra cardiac area is markedly widened to the right indicating enlargement of *the mediastinal glands*

B Three weeks later There are myriads of fine nodular densities scattered irregularly throughout both lung fields

Autopsy revealed advanced miliary tuberculosis

calcific shadow known as the Ghon s lesion results Similarly the enlarged hilum glands shrink and become calcified These calcific shadows persist for the remainder of the patient s life and should be considered as merely healed scars not as evidence of clinical tuberculosis It must be borne in mind that coccidioidomycosis histoplasmosis and other conditions may also heal by calcification

B) Miliary and Pneumonic Tuberculosis —An active pulmonary or glandular tuberculous lesion which extends or ruptures into a bronchus results in a wide

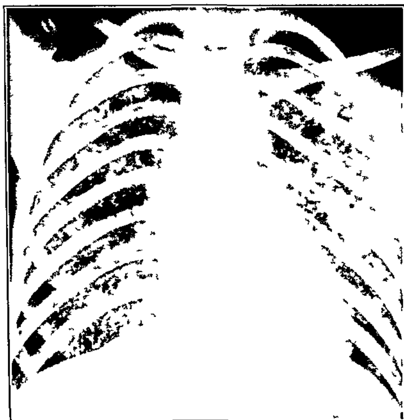


Fig 64 —Miliary Tuberculosis

Myriads of small areas of nodular density are scattered diffusely throughout both lung fields The hilus shadows are not enlarged

spread dissemination of the disease throughout the lungs (Figs 63 64) Miliary tuberculosis or the pneumonic form may occur (Fig 72 p 130) This is a serious development and results fatally in many instances Rarely the widespread type of tuberculosis heal with extensive fibrosis and calcification The enlarged lymph nodes in caseous mediastinal tuberculosis are most commonly seen in the para tracheal region and may extend for a considerable distance into the lung fields The mediastinal shadow may be widened on one or both sides with sharply out

lined lobulated or irregular lateral margins The posterior mediastinum is obscured and the condition may closely simulate neoplasm lymphoma or enlargement of the thymus The trachea may be displaced or narrowed and the carina may be widened Depression or compression of the main bronchus may occur

II Adult Types of Tuberculosis (Figs 65 71) – Tuberculosis in the adult may develop from reactivation and extension of the primary, childhood lesion or more commonly as the result of reinfection by way of the air passages Definite lesions may be found in the lung within 2–3 months after exposure The process is most commonly seen in the infraclavicular portion of the lung field (Fig 6) The onset may be insidious with few or no clinical manifestations Roentgen studies demonstrate the infection soon after its inception as an area of irregular mottled density in the first to third anterior interspaces The lesion begins as

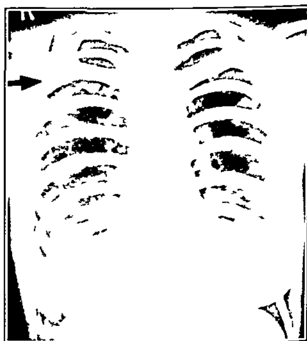


FIG 6 —Minimal Tuberculosis

There is diminished radiance at the right apex and a small area of mottled density in the peripheral portion of the right first interspace anteriorly *The density presents irregular* poorly defined margins and is characteristic of early tuberculosis

a focus of infiltration with bronchopneumonia and caseation of the affected portion of the lung Basal tuberculosis (Fig 73 p 131) is rare but may occur particularly in association with diabetes The small area which represents the early minimal focus may resolve slowly to disappear completely after an interval of a few weeks or months In other cases it becomes fibrotic as evidenced by a change to strand like linear densities (Figs 74 75 p 132) Calcification may supervene in this region after an interval of months or years (Figs 76 77 p 134) More commonly there is progression with increase in the size of the involved area Cavitations develop and are evidenced by rounded areas of increased radiance

within the involved area. In addition to the direct local spread new foci may appear in the same or contralateral lung. On the opposite side a new lesion may appear in the infraclavicular region. The process may also spread through the lymphatics to the parahilar region of the same or opposite side. Basal tuberculosis is rare and usually develops as the result of inhalation of infected sputum with areas of mottled density in the lower or middle lobe. It is usually bronchopneumonic in type. Cavitation and exudation are common. Resorption, fibrosis and calcification may ensue. The process may be due to rupture of a tuberculous lymph gland into a bronchus, direct extension from the hilus, or massive inhalation. The inhalation theory is supported by the fact that many cases occur

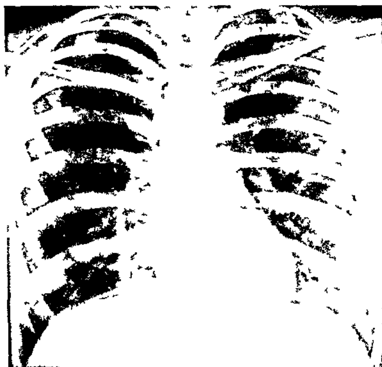


FIG 66 —Tuberculosis Moderately Advanced

The left apex and infraclavicular region show irregular mottled density and diminished radiance. Similar changes are present in the peripheral portion of the right infraclavicular region extending from the first to the third ribs anteriorly. The process appears active. There is no evidence of fibrosis or calcification.

on the right side since the right main bronchus is straight and is directed more sharply downward than the left. However, the disease may also involve the right middle lobe and the left lingular segment.

The course of tuberculosis may be toward increased activity, in which case there is spreading with caseation and cavitation, or toward healing with fibrosis and calcification. Spreading and caseation are manifested roentgenographically by soft mottled densities with irregular poorly defined borders. Cavitation

results in rounded or ovoid areas of increased radiance bounded by a dense narrow band which comprises the capsule of the cavity (Figs 67–69) Fluid levels usually are not present but may occur There is complete or partial lack of lung markings within the cavitations As healing takes place, fibrotic changes are evidenced by linear sharply defined strand like densities extending from the periphery toward the hilar portions of the lung The heart and trachea are deviated to the affected side and there is narrowing of the interspaces There is frequently an associated pleuritis with elevation irregularity and tenting of the diaphragm The hilus shadows may be elevated (Fig 74 p 137) Pleuropericardial adhesions are evidenced by irregularities at the margins of the heart shadow Calcification represents the end stages of healing and is manifested by



Fig 67 —Advanced Bilateral Tuberculosis with Large Cavitations

There is advanced bilateral tuberculosis Multiple cavitations are present bilaterally The heart shadow is deviated to the left The left diaphragm is flattened and irregular in outline and the left costophrenic angle is shallow indicative of pleuritis The heart shadow is small in size and there is marked wasting of the muscles manifested by the thinning of the soft tissue shadows in the supraclavicular and axillary regions

irregular poorly defined areas of marked density of varying size scattered irregularly through the lungs and at the hila

It is important to determine not only the character of the disease but also its extent Standardized terms have been generally accepted The disease is considered minimal if the affected area is less than the width of an interspace (or rib) shadow as seen on a routine full size chest roentgenogram and if no evidence of cavitation is present (Fig 65) This type of lesion may occur anywhere in the lung but is most frequently found in the peripheral portion of the first and second interspaces on the right side Small areas may be obscured



Fig 68 —Adv nced B lateral Tuberculo is with Multiple Cavitations

There are multiple avitations in both lung fields The d se se is far advanced as evidenced by the exten ive mottling throughout both lung fields The heart and mediastinal contents are d spl ced to the right The upper interspace are markedly narro ed more on the right side The heart shado small and there is marked wa tin of the muscles of the body common occurrenc in advanced tuberculosis and other wasting disease

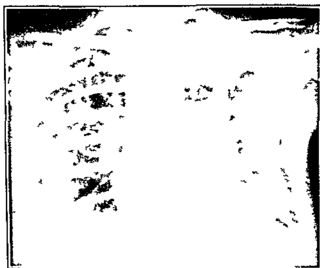


Fig 69 —Advan ed Bilat ral Tub rculo is ith Cavities

Th re i advan ed bilat ral tub r ulosi Th d se s more marked on the l ft and th r re larg ca itations in the left infra la cular regi n and at the left pex There is a ring shadow adj ent to th ri ht lung root

by the overlying rib scapula or clavicular shadow and may require stereoscop views or projections in the lordotic position for clear visualization Moderately advanced cases are those in which the affected portions of the lung comprise all or the greater portion of a lobe or if a cavity measuring up to 4 cm in diameter is present (Fig 66) In the presence of multiple cavitations the disease is considered to fall into this classification if the combined sum of the diameters of the cavities totals 4 cm or less at this stage The process is most apt to involve the



Fig 70 — Advanced Bilateral Tuberculosis

There is involvement of the upper lung fields and the apices The process extend to the level of the third interspaces anteriorly There are multiple small cavities on the left The right infraclavicular region shows evidence of healing with fibrosis and calcification

apical and upper portions of the lung and frequently assumes a triangular or fan like shape the base of the triangle being directed toward the periphery and the apex extending to the upper or mid portion of the lung root The disease is considered to be far advanced when there is multilobar involvement or the cavities are larger than 4 cm in diameter (Figs 67–70)

The progress of tuberculous lesions is followed by serial roentgenograms How frequently examinations should be made depends on the therapeut

measures being used and the clinical findings The extent of collapse in pneumo thorax therapy is best shown by roentgen study and frequent observations may be required during this form of treatment The progress of re expansion of the various lobes or the entire lung the healing of the lesion and the presence of fluid adhesions or other complications are demonstrable In pneumoperitoneum oleothorax and other forms of therapy the roentgenologist may supply important data with reference to the efficacy of the measures employed the progression of



FIG 71 —Advanc d Bilateral Tuberculo is Pleural Effusi n at the Left Base

Both api e and infraclavi ular reg ons show diminished radian e with extensive mottled density *The proce s fibroc l th in nature There i uniform dens ty at the left base* with obliteration of the outline of th diaphragm the apex of the heart and the costophrenic angle The density at the l ft base r es l igher in th axilla than in the m d portion of the hest indic t e of flu d Ther is p leural th ckening in the left lo er lung fi ld adjacent to the border of the heart The heart and trachea are de iated to the right The upper interspaces are narrowed

the disease and the determination of modification or discontinuance of the treat ment After thoracoplasty the roentgenogram affords the most satisfactory method of ob erving the results of surgical intervention (Figs 79 80) In the average case it is the usual practice to carry out *x* ray examinations at intervals

of one to three months in those under active treatment Rarely tuberculosis appears to resolve or absorb completely In most instances however the process heals by fibrosis and calcification resulting in a permanent scar in the affected portion of the lung After healing has taken place roentgen study is best made at intervals of six months to one year unless the clinical evidence warrants more frequent observations It is not possible to determine the question of activity or quiescence of a lesion from a single roentgen study repeated or follow up examinations however are of the utmost value and afford a graphic method of studying the progression of the disease process



FIG 72 —Tuberculous Pneumonia

The left lung field is uniformly dense except for a small area at the peripheral portion of the base The upper left interspaces are narrowed and the left chest is smaller than the right There is diffuse mottling in the right infraclavicular region and the para cardiac portion of the right lower lung field *The trachea and heart are not deviated* Tubercle bacilli were present in the sputum

Less common forms of tuberculosis comprise 1) Tuberculous bronchiectasis 2) Miliary tuberculosis 3) Tuberculoma 4) Tuberculous pleurisy 5) Basal tuberculosis and 6) Fibroid tuberculosis

1 **Tuberculous Bronchiectasis** —Bronchiectasis occurs in chronic tuberculosis particularly in basal lesions The process usually begins as a tuberculous bronchopneumonia Caseation brings about destruction of the bronchi and parenchyma of the lung with production of numerous small localized areas of necrosis which form cavitation of varying size Fibrosis and bronchostenosis develop and result in scarring with atelectatic changes Bronchography is important to delineate the bronchiectasis or bronchial obstructions and may be used safely

despite the common belief that iodized oil studies are contraindicated in the presence of a tuberculous process

2 **Miliary Tuberculosis** —Miliary tuberculosis is most often seen in infancy and childhood but also occurs in adults of all ages The changes in the lungs may be demonstrable within one month or less after exposure The roentgen findings (Figs 63 64) are those of multiple fine small discrete areas of increased density scattered diffusely throughout the lung fields The changes may be more marked on one side or in one portion of the lung although most often the distribution is symmetrically bilateral The roentgenogram must be made with short exposure time and the patient be completely immobilized as the slightest respiratory movement may obliterate the densities in the lungs The hilus shadows are usually enlarged and lobulated There is no evidence of a primary focus in the lungs In differential diagnosis it is important to exclude sarcoidosis miliary forms of metastatic carcinoma fungus diseases and congestive changes



Fig 73 —Basal Tuberculosis

A There is an area of irregular mottled density in the lower third of the left lung field The left diaphragm is hazy elevated flattened and its excursions are markedly limited The left costophrenic sinus is obscured There is marked retraction of the interspaces on the left side and the left lung field is distinctly smaller than the right Sputum studies were positive for tuberculosis

B Three weeks later There has been marked extension of the disease the changes now involving the middle and lower third of the left lung field The left diaphragm and costophrenic angle are obscured The narrowing of the interspaces on the left is more marked than previously and the heart and mediastinal contents are deviated to the left

3 **Tuberculoma** (Fig 78) —The tuberculoma is a solitary lesion usually a rounded area of density and may occur in any portion of the lung The margins of the tuberculoma are sharply defined smooth in contour and show no lobulation The lesion may very closely simulate a metastatic neoplasm bronchiogenic cyst hamartoma or a collection of encapsulated fluid It most probably represents a first infection tuberculosis Calcific deposits may occur as a thin incomplete margin about the peripheral portions of the tuberculoma and represent incomplete calcification of the process The roentgen demonstration of an area of density in the lung during a routine study is in most instances the first intimation

of the presence of this lesion as no symptoms are usually associated with the tuberculoma Neoplasm is practically always the first diagnosis In many cases a final conclusion cannot be reached prior to operation and microscopic examination of the specimen

4 **Tuberculous Pleurisy** — A pleural effusion in many instances is the first manifestation of the existence of tuberculosis The fluid is usually basal and may be either small or large in amount The effusion may obscure the underlying pulmonary lesion and an etiologic diagnosis is not possible until the fluid has

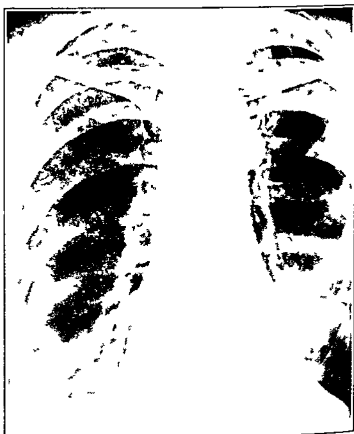


Fig 74 —Fibroid Tuberculosis Elevation of Left Hilum
The left hilum is markedly elevated There is fibrotic density in the paravertebral portion of the left upper lung field and at the left base fibroid tuberculosis

been removed or absorbed Pleural adhesions may remain after the disappearance of the effusion and are manifested by elevation limitation irregularity or tenting of the diaphragm Pleuropericardial adhesions produce irregularities along the cardiac border Fluoroscopic studies are essential for the demonstration of pleural or pleuropericardial adhesions Thickened pleura may produce extensive areas of density in the lung fields usually at the base

5 **Basal Tuberculosis** —Basal tuberculosis is rare but occurs with sufficient frequency so that the possibility must constantly be borne in mind The roentgen findings are those of an irregular area of mottled density which may closely

simulate a pneumonic or neoplastic process (Fig 73) The disease is particularly apt to occur in individuals with low resistance to tuberculosis Tubercle bacilli are found in the sputum in large numbers and the patient presents the characteristic clinical manifestations of active pulmonary tuberculosis

6 **Fibroid Tuberculosis** (Figs 74 75) —Patients with old healed tuberculous lesions may show marked retraction of the involved portions of the lung with narrowing of the interspaces elevation of the diaphragm and marked ipsilateral displacement of the heart and trachea The silhouette of the heart may be completely obliterated by the overlying fibrotic densities in the surrounding lung Because of the decrease in the volume of the diseased lung compensatory



Fig 75 —Fibroid Tuberculosis Left

There is diffusely diminished radiance over the entire left lung field the changes being most marked at the apex and in the upper third of the lung field The trachea is deviated markedly to the left (black arrow) The heart shadow is displaced to the left The left diaphragm is elevated flattened and irregular in outline The left costophrenic sinus is shallow There is narrowing of the interspaces on the left The right lung field shows compensatory emphysema

emphysema of the uninvolved areas may ensue with herniation of the lung into the affected side of the chest

Differential Diagnosis Tuberculosis may so closely simulate many other diseases that accurate diagnosis from a roentgen study alone is frequently impossible Pneumonia particularly of the virus type may produce changes identical with those in active tuberculosis In lobar pneumonia of the upper lobe an important differential point is that the extreme apex of the lung is usually of normal radiance the density extending from the level of the interlobar septum



Fig 76 —Healed Tuberculosis

There is an irregular area of calcific density in the peripheral portion of the right upper lung field slightly below the clavicle Multiple fibrotic strands extend from this area to the upper margin of the hilum The hilus shadows are increased in width and density more on the right The changes are characteristic of healed tuberculosis



Fig 77 —Healed Tuberculosis with Calcification

There are multiple areas of calcific density in both upper lung fields more on the le
healed tuberculosis

to the first interspace anteriorly In virus pneumonia the rapid change in the character of the process in the lung in a few days usually suffices to establish the correct diagnosis Similarly influenzal pneumonia and Loeffler s syndrome (eosinophilic pneumonia) may produce confusing pictures in which follow up studies are essential to exclude tuberculosis Neoplasms both benign and malignant are frequently confused with tuberculosis Silicosis sarcoido i and a host of other diseases may produce changes closely simulating tuberculosis It must be stressed that many diseases occur in association or simultaneously with tuberculosis Careful clinical correlation is necessary for correct diagnosis and the clinician and roentgenologist must cooperate in this as in other diagnostic problems if the patient is to obt un the optimum benefit of medical consultation Studies of the sputum and gastric contents in search for the tubercle bacillus are essential as the finding of the etiologic agent is in the final analysis the most accurate method of arriving at a diagnosis



Fig 78 —Tubercul ma

There is a solitary r unded area of increased density in the l ft lo er lung field adjacent to the heart border The margins of the les on are sharply defined and smooth n outl ne No calcific deposits are demonstrable within the invol ed rea and the lesion closely simulates m tastati carcinoma sarcoma yst ham rtoma or encapsulated fluid The patient pre s nted no symptom The le ion was disco ered dur ng roentgen study of the lun s

ROENTGEN ASPECTS OF THERAPEUTIC PNEUMOPERITONEUM IN PULMONARY TUBERCULOSIS

Artificial pneumoperitoneum is coming into widespread use in the treatment of pulmonary tuberculosis and also in intra abdominal tuberculosis It has been known for many years that during the second and third trimesters of pregnancy tuberculous women may show marked improvement and that after the termination

of the pregnancy when the physiologic elevation of the diaphragm has ended a… the diseased lung has again expanded disastrous results frequently follow Th… one of the chief aims of pneumoperitoneum is to continue this diaphragm… elevation by substituting air for the enlarged uterus Air oxygen or nitro… are used and the technique does not differ from that employed in diagno… pneumoperitoneum As the injections are frequently done under fluoroscopic control and since the radiologist is frequently called upon to determine the amount and distribution of the air a thorough knowledge of this technique important The procedure may be used in addition to phrenic nerve block in association with artificial pneumothorax and as a supplement to thoracoplasty or the paraffin pack Since the method is completely reversible it has cert…



Fig 79—Thoracoplasty Old Healed Tuberculosis
There is absence of the upper and middle left ribs The left chest is collapsed and the left scapula is displaced medialward There is a marked scoliosis to the left in the cervi… dorsal region The right lung field presents a moderate degree of emphysema

advantages over other methods Important complications include asci… intestinal perforation peritoneal inflammation atrophy of the diaphragm air e… bolism massive atelectasis accidental pneumothorax mediastinal emphyse… cardiac decompensation enlargement of inguinal and umbilical hernia and scrotal pneumatocele The roentgenologist has an important place in determi… and evaluating both the indications and contraindications as well as assist… in the technique of administration and study of complications which may foll…

The roentgen effects of pneumoperitoneum (Fig 81) are 1) Elevation of the diaphragm and marked limitation of diaphragmatic excursions The elev… tion is usually bilateral or it may be unequal on the two sides and at times reac…

10 cm or more 2) There is a marked diminution of lung volume which may amount to 25 or 35 per cent reduction of chest capacity There is also compression of cavities The bronchovascular markings appear crowded together and there is a definite change in the position of the heart with widening of the mediastinal shadow 3) There is separation of the subphrenic viscera especially the stomach liver and spleen from the diaphragm 4) Intra abdominal adhesions may disappear It is not definitely understood whether the effectiveness of the procedure depends on the pulmonary rest the better drainage of the bronchial trees and cavities or pulmonary congestion lymph stasis and anoxemia



Fig 80 —Thoracoplasty

The seven upper left ribs have been almost completely removed with consequent collapse of the upper and middle portion of the left chest (white arrow) The heart and trachea are deviated to the left The right lung field shows a moderate degree of emphysema with diffuse mottling fibroid tuberculosis

In view of the widespread use of the roentgen method of study in the determination of perforations of the intestinal tract the roentgenologist must be aware that this procedure has been carried out Otherwise studies of the abdomen or urinary tract may cause confusion and result in erroneous diagnosis It must be borne in mind that the gas may be retained in the abdomen for several weeks sometimes as long as two months Small amounts of gas may easily be mistaken for rupture of the hollow viscera or abscesses containing gas The accumulations of gas in the abdominal cavity with the patient lying down may closely simulate cysts and abscesses or otherwise cause confusion in diagnosis

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PULMONARY CALCIFICATION IN HISTOPLASMOSIS

A great deal of evidence has been accumulated to support the concept of an etiologic relation between non tuberculous pulmonary calcifications and a benign form of histoplasmosis Studies by Zwerling and Palmer showed that the incidence of pulmonary calcification closely paralleled a positive reaction to histoplasmin and that this parallelism did not exist with positive tuberculin reactors There is a wide geographic variation in the occurrence of the calcifications A very high incidence was noted in the nurses studied in Kansas City Missouri



FIG 81 —Therapeutic Pneumoperitoneum in Advanced Pulmonary Tuberculosis

Pneumoperitoneum was instituted as a therapeutic measure The tuberculous process is more marked on the left side The superior margins of the liver and spleen are clearly outlined The left diaphragm is markedly elevated

and these individuals showed a similar increase in sensitivity to histoplasmin The calcification is scattered multiple and bilateral and may be miliary in type (Figs 82 83) There is no means of distinguishing by roentgen methods between the lesions due to tuberculosis and those due to histoplasmin The disease appears to be caused by infection with the fungus Histoplasma Capsulatum and apparently has an active stage which is similar to that of pulmonary tuberculosis The infection with this fungus is widespread and usually benign

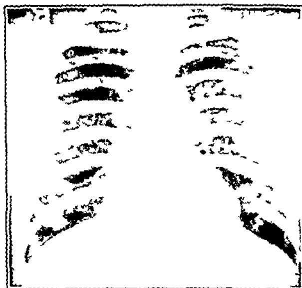


Fig 82 —Pulmonary Calcification in Histoplasmosis

There are multiple small discrete areas of calcific density throughout both lungs The patient showed a positive reaction to histoplasmin There were no pulmonary symptoms He entered the hospital because of a marked swelling in the left parotid region Involvement of the parotid occurs frequently in histoplasmosis

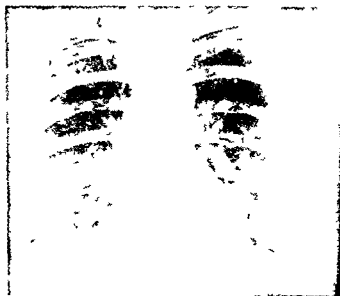


Fig 83 Histoplasmosis

There are small rounded areas of calcific density scattered throughout both lung fields The areas are sharply defined and smooth in outline There is no evidence of pulmonary tuberculosis roentgenologically or clinically The changes are typical of the calcifications due to histoplasmosis

In tuberculosis the degree of calcification and the frequency with which it develops vary directly with the age at which the tuberculous lesion began. Calcified pulmonary foci are found most frequently during the second and third years after the lesion is first observed. In the youngest age group, those under 5 years, calcification follows tuberculosis in 76.5 per cent of the cases. The calcification rate declines progressively in older children and is present in only 2.4 per cent of the cases in which the onset of tuberculosis was between the ages of 15 and 19. Two hundred normal children were studied in southwestern Ohio with chest roentgenograms made one month after birth and every six months thereafter for the first two years and at yearly intervals thereafter. Tests with tuberculin and histoplasmin were also carried out in these children. One hundred and seventy children one year of age or older showed 44.7 per cent positive to histoplasmin and 15.3 per cent were reactive to tuberculin. Calcification was observed early and was apparent in 9 children in the first twenty-four months of life and in 45 others before the age of 4 years. These studies support the idea that pulmonary calcifications are very frequently caused by the agent which produces sensitivity to histoplasmin.

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SARCOIDOSIS

In 1899 Boeck published a report on the disease which has since come to be associated with his name. Since that time many cases have been discovered in practically every country in the world. As the manifestations of the condition are so varied, the disease is actually much more common than has been suspected. It is seen at any age but is most common from 15 to 50. An unusually large percentage of the cases have occurred in Negroes. It is also common in the white race, especially in the Nordic group. The disease has been reported in siblings on many occasions. The condition may persist in characteristic form and with practically no change for indefinite periods, sometimes for years. In other instances resolution takes place in a few months. The lesions may progress in one area and disappear in another. In some instances the disease resolves completely, leaving little or no trace. In others sclerosis gradually transforms the granuloma into a relatively acellular fibrous nodule or mass. Practically every organ in the body has been found to be involved. While usually benign, the course may be prolonged, erratic and unpredictable. A characteristic feature of the condition is the wide dissemination of the disease with absence of significant symptoms. The presence of diffuse pulmonary infiltration is often discovered by accident on routine chest films. In some



FIG. 84.—Sarcoidosis.

There are large lobulated masses of glands at the roots of the lungs with prominence of the linear markings in the lower lung fields.

instances however there is tiredness weakness poor appetite loss of weight joint pain and low grade fever These symptoms apparently correspond with active dissemination of the disease since they tend to occur when new areas are appearing and subside as the disease enters the chronic phase during which the process stabilizes or regresses Recurrences are frequent with the development of new manifestations at a later date

The lymph nodes are very apt to be involved particularly in the intrathoracic region There is a marked increase in size of the paratracheal lymph nodes as well as those of the peribronchial group and in the bifurcation area (Fig 84 5 The enlargement is usually symmetrical bilateral and lobulated whereas in tuberculosis it is more commonly unilateral The nodes have little tendency to coalesce Even marked enlargement of the hilus nodes is rarely associated with

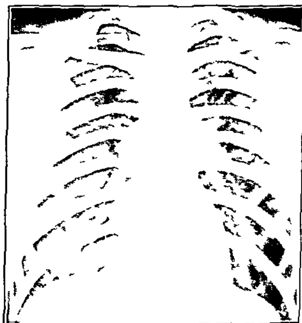


Fig 85 —Sarcoidosis

There is marked enlargement and lobulation of the hilus shadows more on the left, and slight mottling about the roots of the lungs The patient presented the characteristic changes of sarcoidosis in the bones of the hands and feet

pressure or other obstructive phenomena and there is usually slight or no narrowing of the airway This is an important point of differentiation from lymphoma and carcinoma Atelectasis has however occasionally been reported in association with such enlargement The esophagus may be displaced or compressed Other lymph nodes than those in the mediastinum may also be involved The spleen is very apt to be enlarged in some cases very markedly so The liver also is frequently enlarged Involvement of the lung parenchyma is a common feature in this disease (Fig 86) Many of the lung lesions tend to recede and disappear (Fig 87) If a patient with sarcoidosis is followed carefully over long periods lung involvement will be demonstrated in the great majority Here also there is a very striking lack of correlation between the degree of demonstrable

pulmonary disease and the symptoms, the patient having no complaints or at most only a mild cough or slight dyspnea. The physical findings tend to be slight or absent unless associated pulmonary tuberculosis is present. In rare instances there is severe and progressive dyspnea. When this occurs it is in association with progressive fibrosing lesions or cardiac insufficiency.

The roentgen picture may be mimicked by a wide variety of conditions. Hematogenous tuberculosis may be closely simulated. Also lymphangitic carcinomatosis or silicosis produces a very closely similar picture. In some instances there are areas of confluent density which suggest fibrotic induration or pneumonic infiltration. In many instances the hilar adenopathy is the first manifestation and pulmonary infiltration has appeared to extend fan-wise into the parenchyma bilaterally at a later date. The early lesions tend to be miliary or of the nodular disseminated type, are usually reversible and frequently resorb without any trace. The linear strand-like type may also clear partially or completely but

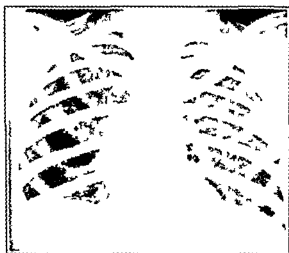


Fig. 86.—Sarcoidosis.

The hilar shadows are increased in width and density, especially on the right side. There is diffuse granular mottling throughout both lung fields.

shows a greater tendency to fibrosis. When parenchymal dissemination occurs the hilar lymph nodes usually regress. The pulmonary infiltration is most commonly in the parahilar regions or the mid zones of the lungs. In some instances the basal portions of the lungs alone are involved. As the pulmonary lesions regress the hilar lymph nodes in some instances enlarge. When interstitial pulmonary fibrosis develops complete regression is usually not possible. This is manifested by delicate striations in the lung fields associated with areas of miliary density which are later transformed into conglomerate lesions of varying extent with nodular or stringy fibrosis. These foci may be patchy or localized so that areas of density may persist while others regress. There may be in association with the fibrosis emphysema, bronchiectasis or extensive contraction of the lung field. Cavities have been described and have been interpreted as being

due to cystic bronchiectasis emphysema and occasionally associated pulmonary tuberculosis Spontaneous pneumothorax may occur About 6 per cent of the cases seem to have *pulmonary tuberculosis supervening* as a late development

Pathologically the fibroid lesions are scattered throughout the interstitial tissues of the lung in a manner which suggests hematogenous seeding There is a predilection for regions about the blood vessels and bronchi the interlobular lymphatics and the subpleural areas There may be a co-existing periarteritis nodosa syphilis or other disease Infiltration of the heart also occurs and this is apt to result in cardiac failure

Associated changes in the bones are very common and are helpful in diagnosis The short bones of the hands and feet are particularly apt to be involved and the lesions are closely similar to those in leprosy Other areas of the skeleton including the skull have also been found to be involved The roentgen changes

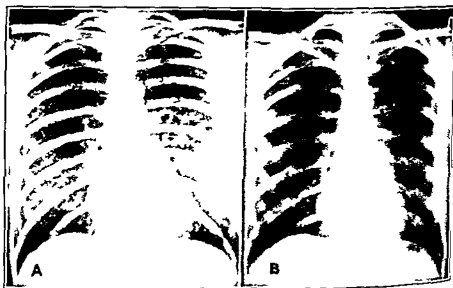


Fig 87 —Sarcoidosis

A There is hilar adenopathy with diffuse mottling throughout both lung fields The changes are more marked on the left

B Four months later There is regression of the pulmonary lesions and decrease in the size of the hilar shadows

in the bones take two main forms 1) A circumscribed type of characteristic cystic areas of rarefaction usually medullary and with little or no surrounding tissues 2) A diffuse form in which multiple small areas of rarefaction produce a finely trabeculated pattern involving large portions of the bone *There is* in these instances frequently an associated broadening of the shaft and thinning of the cortex Both types may co exist and there may be transition from one to the other Externally there may be fusiform swelling *of the fingers* or toes with occasional periarticular subcutaneous nodules Dystrophic changes in the nails occur The swellings are symptomless although there may be slight pain The *periosteum* and the joints are rarely involved In some instances extensive bone destruction causes severe external deformity Many other organs of the body

particularly the skin may show marked involvement Erythema nodosum occurs as an early skin manifestation However this is a non specific manifestation of hypersensitivity and is often seen in association with rheumatic fever tuberculosis and coccidioidomycosis A roentgenographic picture identical to that seen in sarcoidosis occurs in erythema nodosum and periarteritis nodosa which raises the possibility that the conditions may be allied Involvement of the gastro intestinal tract is rare but has been reported and lesions have been described in the stomach the small intestine the appendix and the colon

The disease tends to run a prolonged low grade and unpredictable course lasting from several months to many years In some cases the onset is abrupt and febrile Most often however it is benign and the prognosis is good many patients recovering completely No form of therapy appears to be uniform in success X ray therapy has been tried with beneficial effect in few cases and little or no effect in others The relationship to tuberculosis has been stressed by many authors but has not been proven

Erythema nodosum and periarteritis nodosa may give changes similar to those in sarcoidosis with enlargement and lobulation of the hilum glands and intrapulmonary mottling The lesions in the lungs are less marked or may be completely absent

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PNEUMONOCONIOSIS

Pneumonoconiosis is the disease of the lungs caused by the habitual inhalation of minute particles of mineral or metallic substances

Pneumonoconiosis is a generic term and includes all the chronic fibrous reactions which develop in the lungs a the result of the prolonged inhalation of excessive quantities of injurious dusts The chief agents which may produce pulmonary injuries are sand granite asbestos and beryllium Foreign material in varying amounts is inhaled with every breath of air we breathe Under normal conditions the dust is prevented from entering the lungs by physiologic mechanisms In the nasal passages cilia act as filters The epithelium lining the trachea and the bronchi contains ciliated cells whose function it is to propel small particles of dust in the direction of the mouth There are in the lungs and air passages goblet cells and mucous glands which keep the membranes moist and serve for protection The rate of ciliary transport is estimated to be approximately 0 2 0 4 mm per second The constant vibratory motion of the cilia keep the lower passages of the lung almost free of small particles In the presence of large and dense particles the action of the cilia is insufficient to result in expulsion from the lungs Another protective mechanism is made up of the smooth muscle bands which are present in the tracheobronchial tree as far as the distal end of the alveolar ducts at which point the muscles form a type of sphincter about the openings which lead to the atria of the alveoli The lungs possess rhythmic movement of a peristaltic nature which consists of a lengthening and widening of the bronchial lumen on inspiration and a shortening and narrowing on expiration the lung roots moving downward during inspiration and upward in expiration The peristaltic waves appear to synchronize with the expiratory phase of respiration beginning at the periphery of the bronchial tree and progressing to the stem bronchi The function of the waves is to propel liquid content and empty the bronchial tree with or without accompanying ciliary action The peristaltic action of the bronchi thus supplements the action of the cilia Collected particles when mixed with mucous tend to stimulate the cough reflex which results in elimination of the offending agent The cough reflex originates in the throat esophagus nose and bronchi The chief sensory points of the cough reflex occur at the bifurcation of the trachea below the true vocal cords and at the pleura Beyond the bifurcation of the main bronchi there is practically no cough reflex Voluntary coughing also assists in the expulsion of foreign material It must be stre sed that while in health the cough reflex is a protective mechanism it may in the presence of disease increase the danger of aspirating foreign materials

Pneumonoconiosis is a combination of the two words from the Greek pneumon (lung) and konis which signifies dust The term is applied to all conditions in the lungs resulting from the inhalation of dust The most important of the pneumonoconioses are 1) Silicosis the disease of the lungs caused by the inhalation of silica or quartz 2) Asbestosis which results from the inhalation of

silicate of magnesium Silicatosis is the term applied to the group of dust conditions caused by the inhalation of mineral dust in which silica is combined with various bases 3) Anthracosis a condition characterized by the deposit of black carbon pigment in the lung and usually seen in coal workers 4) Siderosis the lesion occurring in workers with metals particularly metallic oxides which color the lungs varying shades of yellow or brown and 5) Berylliosis the disease caused by the inhalation of beryllium either in the form of dust or fumes Pneumonoconiosis may exist for considerable periods of time without producing symptoms or impairing physical efficiency This is especially true of siderosis chalicosis and anthracosis Dusts with a high concentration of finely powdered silica are most apt to produce serious forms of pulmonary fibrosis and these diseases are of great medical and economic importance The admixture of aluminum



Fig 88 —Silicosis

There is diffuse mottled density throughout both lung fields with extensive granularity In the region adjacent to the right hilum there are massive shadows of increased density with irregular poorly defined borders There is emphysema bilaterally more on the left The heart shadow is deviated slightly to the right There is retraction of the right apex due to fibrotic changes The heart shadow is prominent to the left in the region of the ventricle

calcium and gypsum results in a modification or arrest of the deleterious effects of silica and may retard or inhibit the noxious changes The silicates vary markedly in pathogenicity many being inert some mildly pathogenic and others apparently completely retarding or neutralizing the effects of the free silica

Classification —The classification of the pneumonoconioses may be made according to the physical nature of the dust or by the type of tissue response to the particular agent Others consider the clinical and roentgen features of the particular dust disease Sayers has classified the pneumonoconioses according to both the physical characteristics and the physiologic effect of the dust This classification is the most complete and satisfactory

I *Inorganic Dust*

A Fibrosis producing Silicosis and asbestosis are the most important in this group These dusts are slightly soluble

B Non fibrosis producing Anthracosis is the chief example in this group These dusts are inert and become encapsulated in the tissues or absorbed but do not produce fibrous tissue

C Toxic and/or irritant This group comprises lime dichromate compounds lead mercury and other heavy metals These are corrosive and cause severe local reactions If absorbed into the body in sufficient amount generalized toxic effects appear The dust and also the vapor of these substances are harmful

II *Organic Dusts*

A Non living organic dusts These are toxic and/or irritant

(1) The chief offenders are the benzene and phenol compounds

(2) The allergic dusts These comprise pollens furs feathers and similar agents Asthma hay fever and other allergies result from these dusts

B The living organic dusts These include—

(1) The dusts infected with bacteria and

(2) Those infected with fungi



Fig 89 —Silicosis

There is diffuse irregular mottling throughout both lung field more on the right The hilus shadows are markedly enlarged dense and irregular in outline There is emphysema bilaterally The heart is enlarged The aorta is dilated and tortuous The mottling on the right apex and infra clavicular region is consistent with fibroid tuberculosis The patient had been a granite cutter for twenty years

Silicosis (Figs 88–94)—Silicosis is caused by the inhalation of free silica or quartz particles into the lungs It is the most frequent and disabling of all the dust diseases and is characterized by the production of extensive fibrosis in the lungs Because of the high incidence of this disease it is of great importance to the radiologist and the clinician In the Pilcher district of Oklahoma during the period from 1927 to 1932 7,553 individuals were examined all of whom had been exposed to dust Five thousand three hundred and thirty six had silicosis 742 had silicosis and tuberculosis and 320 showed tuberculosis alone Silicosis is common in the metal grinding and polishing industry in the granite and stone

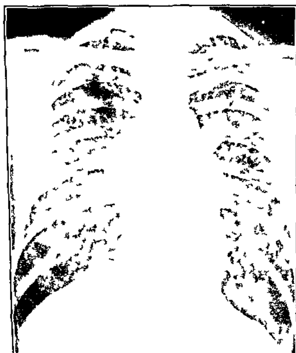


Fig 90 —Silicosis

The hilus shadows are markedly increased in width and density bilaterally There is extensive irregular mottled density throughout both lung fields with diffuse fibrotic changes There is marked emphysema with depression and flattening of the diaphragms and widening of the interspaces bilaterally The heart is vertical in position The patient had been a granite cutter for approximately seventeen years

industry where pneumatic and electric tools are used in iron and steel foundries and also in occupations involving mining excavating and tunneling Sand blasting is very apt to produce the disease Lung disease may develop after very short periods of exposure In the manufacture of abrasive soaps and scouring powders there is a particularly high incidence of silicosis and silicotuberculosis apparently due to the fact that the presence of alkaline soap powders increase the effect of the silica Aluminum and other substances modify and lessen the

deleterious effects of silica on the lung aluminum oxide especially serving to retard the changes

Normally the protective mechanisms of the naso pharynx and bronchi are sufficient to keep the lower air passages free from dust It has been found that particles of silica measuring 0 5 to 2 5 microns in diameter are most apt to produce damage Particles larger than 10 microns in diameter seldom gain admission to the alveoli In asbestosis particles as large as 200 to 400 microns in diameter may be found in the bronchi The important factors in the production of silicosis are the size of the particles of dust their *concentration in the atmosphere* the percentage of free silica and the length of exposure The presence of lung infection or other underlying pulmonary disease may be an important contributory factor



Fig 91 —*Silicosis with Tuberculosis*

There is pneumoconiosis bilaterally the involvement being most marked at the right base There is a marked degree of emphysema In the right infraclavicular region there is extensive irregular mottling with multiple cavities The heart shadow is small The aorta is dilated tortuous and sclerotic There were tubercle bacilli in the sputum

Mouth breathers are more apt to acquire the disease than those with a normal condition of the nose and pharynx Pre existent pulmonary tuberculosis enhances and contributes to the development of silicosis The silica acts as a tissue irritant and produces a *fibroblastic reaction in the lymphoid tissue* with the formation of nodules in the lung As mentioned above alkalies increase the *effect* of the dust while coal dust aluminum and other minerals apparently retard the development of the disease Tuberculosis occurs in a very high percentage of patients with silicosis in some series rising as high as 75 per cent Patients with silicosis show an increased incidence of lobar or bronchial pneumonia *Friedlander* s pneumonia Streptococcus infections and other types of lung disease

Pathology —Foreign material in the alveoli results in the lining cells of the alveoli becoming phagocytic The particles are engulfed in the cell Many

are eliminated in the sputum. The particles which cannot be expelled travel to the pulmonary parenchyma and regional lymphatics within the macrophages and also reach the hilar lymph nodes. Many are deposited in the small collections of lymphoid tissue at the bifurcation of the bronchi and the blood vessels. The increase in the size of the lymphatics results in blockage and slowing of the lymphatic stream. The macrophages become fixed tissue cell and are transformed into fibrotic nodules. There is encroachment on the alveolar and interstitial elements of the lung. The fibrotic nodules coalesce into conglomerate masses and are distributed irregularly throughout the lungs. On microscopic examination



Fig. 92.—Pneumoconiosis. Nodular Type.

There is diffusely diminished radiance throughout both lung fields. The hilar shadows are markedly increased in width and density, more so on the right. There is diffuse mottling throughout both lung fields with nodular densities in the infraclavicular regions and at the right base. There is a moderate degree of emphysema bilaterally.

The patient has been employed as a sand blaster for twenty-one years.

the nodules consist of a dense center of fibrous tissue surrounded by layers of hyaline fibers and multiple small round cells. The lung in silicosis is heavy, firm and large. On cut sections it is hard and gritty and multiple nodules project above the surface. The color is gray or black. The larger nodules of silicosis may show small excavations in their central portion. Tuberculosis is present in many cases and is fibrotic and nodular in character or fibroulcerative with cavities and multiple areas of bronchopneumonia. Caseation is common. There is thickening

of the pleura and the interlobar septa. Diffuse fibrosis, emphysema and bronchiectasis occur. Emphysematous blebs are common. The tracheobronchial lymph nodes are large, dense and irregular. In many instances there is enlargement and hypertrophy of the heart with decompensation and congestion. Terminal bronchopneumonia is common. It must be stressed that the extent of the disease as shown on the roentgenogram does not indicate the degree of impairment of the patient in many cases. Multiple small diffuse nodulations in the presence of advanced emphysema may be more disabling than large localized masses. The disease may remain unchanged for many years or may progress rapidly. The frequent association with tuberculosis and other pulmonary disease is an important factor (Fig. 91). It is necessary to take into consideration 1) the extent and localization of disease, 2) the presence of infection and 3) the presence or absence of disability in the evaluation of each case.



FIG. 91.—Silicosis with Calcification

There is extensive mottling with multiple calcifications in the lung fields. Calcifications frequently develop in silicosis in the absence of tuberculosis. The patient had been a granite cutter for twenty-two years.

Roentgen Manifestations.—In the early stages there is generalized prominence of the bronchovascular markings, diminished radiance and granularity in the middle and lower lung fields and enlargement of the hilus shadows. Multiple rounded discrete areas of density are distributed principally in the central and basal portions of the lung fields along the vascular channels and the bronchial tree (Fig. 92). These nodules may be small, approximately 2–6 mm. in diameter, or large and oval, rounded or irregularly shaped. They may be absent in the apical and peripheral portions of the lungs and in some instances are limited principally to one lobe. While usually uniform in density, they tend to be more dense in their central portions. This is termed nodulation and may closely simulate metastatic carcinoma, miliary tuberculosis, bronchiolitis, fungus disease, sarcoidosis and other lesions. However, in silicosis very extensive nodularity

may be present with complete absence of clinical manifestations or disability Coalescence and enlargement of the nodules result in the formation of extensive large irregular areas of increased density in the lung fields (Fig 94) Massive shadows of increased density may be distributed symmetrically or irregularly unilaterally or in both lung fields the upper and mid lung fields showing the principal involvement The hilus shadows in some instances may show little or no enlargement Multiple strand like shadows occur Emphysema is a prominent feature and involves particularly the basal and peripheral portions of the lungs (Figs 89 91) Pleural changes are manifested by linear densities in the region of



Fig 94 Silicosis with Marked Nodules

The patient was a sand blaster having worked continuously at this occupation for fourteen years There are large masses or areas of increased density throughout the upper and middle lung fields more on the right The masses are rectangular are lobulated and irregular in outline There is very marked emphysema at the bases with a large emphysematous bleb in the left lower lung field (see white arrow)

the interlobar septa and irregularities of diaphragmatic contour Atelectasis of a portion of a lobe or an entire lobe may occur Cardiac hypertrophy with failure is seen in the late stages Chronic fibrosis results in retraction of the apices elevation of the hila and narrowing of the interspaces Calcification and cavitation may occur without tuberculosis being present The calcific deposits are particularly apt to involve the parahilar regions and tend to be granular in

character Infection most frequently tuberculosis may accentuate or modify these changes (Fig 91) Cavities bleb formations thickenings of the pleura pneumothorax pleural effusion and emphysema may occur The diaphragm may be irregular flattened depressed and limited in excursions Spontaneous pneumothorax may occur Body section roentgenography or Bucky diaphragm studies demonstrate distortions and obliterations of the bronchi cavitation calcific shadows and blebs An important manifestation of silicosis is the

ROENTGENOLOGIC APPEARANCES IN SILICOSIS AND THE UNDERLYING LESION

HEALTHY LUNGS AND ADNEXA

Roentgenologic Appearances	*Histologic Appearances*
1 Healthy lungs As defined by the N T A Committee report	1 Essentially the normal tissues of the vascular tree the mediastinum the bronchi and trachea
2 Irregular exaggeration of the linear marking with possibly some beading confined to the trunk	2 Cellular connective tissue proliferation about lymphatic trunks in the walls of the vessels and bronchi Beading may be due to various causes as blood vessels seen on end arteriosclerosis minute areas of fibrosis in lymphoid tissues along the trunk
3 Increased root shadow	3 Cellular reaction in the tracheobronchial lymph nodes with extension along afferent lymphatic trunks

SIMPLE SILICOSIS

4 Nodulation Discrete shadows not exceeding 6 mm in diameter tending to uniformity in size density and bilateral distribution with well defined borders surrounded by apparently normal lung shadow The outer and lower lung fields characteristically show fewer nodules	4 Circumscribed nodules of hyaline fibrosis located in the parenchyma of the lung Occasionally some of these nodules may show microscopic foci of central necrosis
5 Conglomerate shadows that appear to result from a combination or consolidation of nodulation usually with associated emphysema manifested by a Localized increased transparency of the lung with loss of fine detail b Intensification of the trunk shadows by contrast c Depression of the domes with possible tendency toward individualization of the costal components of the diaphragm d Lateral view Increase in preaortic and retrocardiac space with the exaggerated backward bowing of the spine Widening of the spaces between the ribs may or may not be present	5 The result of coalescence of discrete nodules an area in which the nodules are closely packed and areas of the intervening lung replaced by more or less hyaline fibrous tissue The lung architecture is partially obliterated No demonstrable evidence of inflammation Emphysema is a compensatory dilatation of the air spaces with or without thickening of the septum

Silicosis With Infection

6 Localized discrete densities and/or string like shadows accompanying those of simple silicosis described above	6 Strands of fibrous tissue often along trunks and septums with or without areas of calcification indicative of healed infection
7 Mottling shadows varying in size with ill defined borders and lacking uniformity in density and distribution accompanying simple silicosis	7 (a) Areas of bronchopneumonia with or without caseation i e acute infection (b) Lobular areas of proliferative reaction with or without caseation i e chronic infection
8 Soft nodulation The nodular shadows described under simple silicosis (4) have now assumed fuzzy borders and or irregularities in distribution This change may or may not accompany the simple mottling of (7)	8 Perinodular cellular reaction either exudative or proliferative in character
9 Massive shadows of homogeneous density not of pleural origin symmetrically or asymmetrically distributed	9 Extensive area of fibrosis probably due to organized pneumonia of tuberculous or nontuberculous origin superimposed upon pre existing silicotic process Outlines of normal structures may be partially destroyed

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presence of eggshell type of calcification characterized by spherical nodules with a thin calcific margin These may occur in the parenchyma or in the hilar glands and it is believed that they represent calcified areas of tuberculous infection or silicotic nodules with calcific degeneration about their margins It has been suggested that these shadows are due to the inhalation of calcium with the silica

Anthracosis (Fig 96) Anthracosis occurs in coal miners and in city dwellers exposed to dusty atmospheres containing large amounts of smoke The term means black lungs The particles of carbon which find their way into the lung produce a phagocytic reaction similar to that in silicosis However the carbon particles are inert chemically and do not cause local injury to the lung tissue The foreign material may be carried to the liver spleen bone marrow lymph nodes and other organs The affected organs are dark in color but show no local reaction unless silica is also present The pleura contains fibrous adhesions particularly between the visceral and the parietal layers The surface of the lung presents numerous fine black interlacing lines which correspond to the superficial lymphatics Within the lung there are multiple black areas and linear strands with little or no nodulation There is extensive bronchitis interstitial fibrosis bronchiectasis and emphysema In mine workers subjected to the inhalation of coal and silica dust mixtures anthracosilicosis develops characterized by extensive silicotic fibrosis and marked emphysema These patients show a high degree of tuberculosis The lungs may contain large hard masses and scattered discrete nodules The process occurs only in patients exposed for long periods 20 to 30 years The extent of the reaction depends on the relative amounts of coal and silica dust in the inhaled air The pulmonary changes are similar to those which occur in silicosis

Siderosis —Siderosis is caused by the inhalation of metallic iron dust The pathologic changes are due to the presence of silica in the iron ore Uncomplicated siderosis rarely occurs The color of the lungs may be red or black depending on the type of pigment The lung is hard and red or reddish brown in color and shows extensive areas of fibrosis with little if any evidence of silicosis or tuberculosis The black color is seen chiefly in iron workers metal grinders and polishers Electric arc welders also are apt to develop this type of disease due to the fact that the electrodes used in the process contain approximately 99 per cent ferro material The fumes arising from the electrodes contain inorganic material



Fig 9 —Pneumoconiosis Subsequent to the Inhalation of Soap Dust

The patient had been exposed to finely powdered soap dust for a period of three years the course of his employment There was chronic cough and shortness of breath with loss of weight and easy fatiguability The hilus shadows are markedly enlarged and irregular in outline There is extensive irregular mottled density involving the middle and lower portions of the right lung field and the lower half of the left lung field There is marked emphysema bilaterally

particularly finely divided iron oxide The roentgen changes are those of a diffuse pseudo nodular type of fibrosis with marked accentuation of the hilar and peribronchial markings The phagocytic cells contain large amounts of sand pigment There is no evidence of connective tissue fibrosis the reaction in the lung apparently being produced by a type of inert foreign material

Organic Dusts —Workers employed in the processing of animal hairs furs or skin often inhale anthrax bacilli Farmers engaged in threshing rib at a 1 grain may inhale aspergillus fungi Tuberculosis and pneumonia are common

these patients. The disease is primarily due to the inhalation of dust particles containing living bacteria or fungi and the disease truly speaking is not pneumonoconiosis. Dusts which are not infected seldom cause disease. Allergy may be caused by the inhalation of organic dusts. The patients develop hypersensitivities which are similar to those in other allergic diseases. Byssinosis is caused by the inhalation of cotton dust and bagasossis is caused by the inhalation of the dust waste of sugar cane.

Asbestosis.—Asbestosis is a form of pneumonoconiosis which results from the inhalation of hydrated magnesium silicate. An important feature in this disease is the finding of asbestos bodies in the lung and sputum. The bodies are made up



Fig. 96.—Anthracosis.

There is diffuse mottling throughout both lung fields with extensive nodularity and conglomeration of the densities in the mid lung fields more on the left. The infraclavicular regions and the bases show marked emphysema.

of a nucleus of asbestos surrounded by iron containing deposits. They are identified by their yellow color and the fact that they do not stain with ordinary histologic stains but become blue when treated with potassium ferrocyanide. On pathologic examination there is a diffuse fibrosis and contraction of the lung with multiple asbestos fibers and asbestos bodies. The fibrosis extends into the apices and surrounds the pulmonary endarteries. There is marked thickening of the pleura, the pericardium and the interlobar and intrapleural connective tissue with emphysema particularly at the bases. The incidence of tuberculosis is very low among asbestos workers. The heart and pericardium are affected

more than in other forms of pneumonoconiosis with enlargement and prominence of the pulmonary vessels due to engorgement or perivascular fibrosis. The heart is frequently rotated and displaced secondarily to the emphysema and pulmonary fibrosis. The clinical manifestations consist of dyspnea on slight exertion, cough, easy fatigability and loss of weight. The physical examination reveals dullness over the lower lung fields and hyperresonance in the upper portion of the chest consistent with fibrosis at the bases and emphysema of the apices. There is marked limitation of chest expansion. Rales are present only with associated bronchitis or bronchiectasis.

Roentgen Findings (Fig. 97). In the early stages there is slightly increased density and haziness at the bases. The densities are finer and more granular than

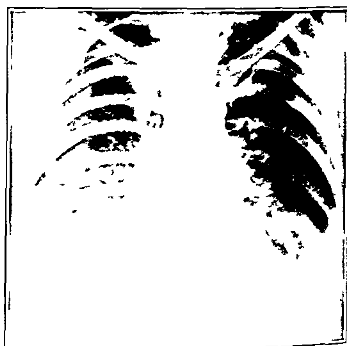


Fig. 97 — Asbestosis

There is diffusely diminished radiance with a granular or ground glass appearance involving both middle and lower lung fields, the characteristic findings in asbestosis. The hilus shadows are slightly enlarged. The apices and upper lung fields are emphysematous.

in silicosis, nodular or patchy areas not being present. In the moderately advanced stage there is diffusely increased density over the lower lung fields. The diaphragms are hazy and limited in excursions and the costophrenic angles are obliterated. There is a fine lace-like network of fibrosis over the middle and lower lung field producing a ground glass appearance. The bronchovascular markings are increased. Pleural and pericardial thickenings are common. The diaphragms are elevated and limited in excursions. Bronchitis and bronchiectasis frequently occur in association with these changes. Right ventricular hypertrophy and heart failure supervene, the heart changes being secondary to the pulmonary fibrosis.

Berylliosis.—Berylliosis results from the inhalation of finely divided beryllium compounds. The disease is characterized clinically by pulmonary insufficiency, the major involvement being in the lung. The lesion is a granuloma similar to that which occurs in sarcoidosis. The disease is manifested by an acute and chronic stage, the chronic form developing after a latent interval between the termination of exposure to beryllium and the beginning of the disease. The condition is relatively new, having been reported in this country only since 1943. Beryllium is a chemical element very similar to magnesium and calcium and occurs in rocks as a complex aluminum beryllium silicate. The disease has not been reported in those mining, handling or shipping the compound in the form of silicate. The recorded cases have occurred among workers in the processing plants, fluorescent lamp manufacture, laboratory research, the preparation of lamp phosphors, the manufacture of ceramics containing beryllium, beryllium alloys and in radio work. Cases have also occurred in the neighborhood of plants as the result of exposure to exhaust gases and fumes containing beryllium. The incidence of the disease is variable and is apparently directly proportional to the degree of exposure and type of compound used. The more soluble forms of beryllium are more apt to produce the disease than the less soluble compounds. Age and race are not important factors. Repeated past respiratory infections predispose to the disease. When beryllium compounds are inhaled some of the fine particles remain in the lung. Swallowing the compounds does not produce clinical manifestations.

Pathologic Changes.—Beryllium compounds may produce acute inflammatory, exudative and proliferative reactions and chronic granulomas. The acute reaction in the lung consists of a generalized diffuse pneumonitis with exudates in the alveoli composed of edema fluid and fibrin with macrophages. After a week or more these areas form an organized pneumonia. The process is similar in many respects to that of acute chemical pneumonitis from other causes. In the chronic form the pathology is a diffuse granulomatosis very similar to that in sarcoidosis. There is marked emphysema, multiple scattered nodules and a diffuse fibrosis which is both interstitial and nodular in association with the granulomatous reaction. The granulomas are formed within the alveolar spaces and have a central portion of fibrinoid material with peripheral fibrosis and mononuclear infiltration. There are multiple giant cells. The pulmonary manifestations are characterized as acute and chronic. The acute stage may be followed after an interval of years by the chronic types. Intermediate varieties occur.

Clinical Symptoms.—In the acute form there is an insidious onset with dry cough and substernal pain followed by dyspnea and cyanosis. There is severe anorexia, increased respiratory rate and prostration but no fever. The disease may last from a few weeks to several months. Resolution tends to take place. In the chronic variety the disease usually comes on after the termination of exposure. The onset may be delayed for months or many years. There is slight loss of weight, weakness, fatigability and frequently a history of a cold that has persisted for a long time. The cough becomes more severe and pulmonary insufficiency ensues. Exertional dyspnea is common. The symptoms do not differ greatly from those in many other chronic pulmonary diseases. There is progressive loss of weight and anorexia. The cough is usually non productive and is worse in the morning. Exertion may initiate or aggravate the cough. Blood

streaking is common Pain in the chest is slight or absent when present it substernal and aggravated by breathing and coughing A low or normal b[illegible] pressure is present in most cases *Cyanosis and clubbing of the fingers* are co[illegible] monly seen in the advanced stages Cardiac decompensation develops w[illegible] increased dyspnea orthopnea and edema of the extremities Chronic [illegible] pulmonale is prominent There is a marked reduction in the vital capaci[illegible] As the disease progresses the patient develops rapid shallow breathin[illegible] T[illegible] changes in the chronic form of disease are similar to those seen in silicos[illegible] cardiac disease The liver is apt to become engorged with abdominal pain naus[illegible] and vomiting

The diagnosis of the disease is made on the basis of the following 1) *occupational history of exposure to beryllium compound* 2) The characteri[illegible] type of onset and clinical course 3) Roentgen signs 4) The clinical laborat[illegible] findings with beryllium in the tissues and the urine Because of the similar[illegible] of the granuloma of beryllium to that of sarcoidosis diagnosis by biopsy fr[illegible] quently cannot be made The physical findings alone do not establish the di[illegible] nosis However a history of exposure may lead to a probable diagnosis T[illegible] chief conditions to be discussed in differential diagnosis are sarcoidosis erythe[illegible] multiforme periarteritis nodosa chronic pneumonia miliary tuberculosis me[illegible] astinal lymphoma lymphangitic spread of carcinoma mitral stenosis Hodgkin[illegible] disease moniliasis other fungus diseases and the pneumonoconioses

Roentgen Aspects —Acute stage—There is increase in the linear marki[illegible] with *granularity very similar to that in pulmonary congestion* Within two t[illegible] three weeks after the onset there is a ground glass density throughout the l[illegible] fields This may not involve both lungs uniformly or completely and often [illegible] confined to the mid lung or base of one or both sides As the disease progress[illegible] the shadows become denser and simulate a consolidation of either the loba[illegible] o[illegible] bronchial type As the condition improves a granular and nodular pattern w[illegible] conglomerate masses develops in the lung There may or may not be signs o[illegible] *residual fibrosis in the later stages Usually clearing takes* place within one to four months The roentgen picture is not pathognomonic and cannot be differ[illegible] entiated from other acute pneumonias due to many causes the diagnosis bein[illegible] dependent on the history of exposure together with the roentgen findings

Chronic Forms —There is a delay in the onset of symptoms and the roent[illegible] signs Wilson classifies the roentgen findings as follows 1) a granular type 2) a granulo nodular form and 3) a nodular variety with emphysema Th[illegible] earliest recognizable abnormality is a fine sand like *pattern or stippling* throu[illegible] out both lungs This is distributed uniformly from the apices to the base a[illegible] *apparently represents an interstitial thickening* with congestion and edema Th[illegible] changes are more discrete than those usually seen in pulmonary edema and a[illegible] considered an early fibrous change with small granulomas This sta[illegible] e ma[illegible] persist for weeks or months and rarely many years At this stage there [illegible] prominence of the root shadows However the prominence of the lun[illegible] ma[illegible] shadows and vascular markings may be obscured or absent There is no emph[illegible] sema or pleural or cardiac complications The second stage shows increas[illegible] *nodulation* with a reticulated pattern and sand like background There [illegible] nodularity which is more or less uniform in size and distribution althou[illegible] h o[illegible] portion of the lung may be more markedly involved than the other The l[illegible] root shadows and linear markings are indistinct Paratracheal and hilar ma[illegible]

may be demonstrable. There is little or no emphysema and no evidence of cor pulmonale. This may persist for months and may progress to stage three. In the third or nodular stage with emphysema, the nodular shadows increase in size but remain within the measurements of 5 mm in diameter and may be as small as 1 mm. Between the nodules there are clear areas of varying size which are due to emphysema with intervening areas of linear fibrosis. There is marked emphysema at the bases which gives the false impression that the process is clearing. The diaphragms are limited in excursions. The upper lobes become partially atelectatic and their density is increased by the coalescence of the



Fig. 98. Beryllium Pneumonitis (Berylliosis)

The lung fields show extensive diffuse irregular patches of mottled density. The changes are generalized but are most marked about the right hilum. The density is granular in character. There is emphysema bilaterally.

nodular lesions. Signs of cor pulmonale become apparent at this time. Spontaneous pneumothorax occurs commonly and may involve one or both sides. Pleural effusion does not take place and the air in the pleural space usually absorbs in about two weeks without complications. Several cases in Wilson's series developed urinary tract calculi. The bones and other portions of the body show no abnormalities. The chronic form is manifested by a small granuloma which manifests itself as a granular or nodular shadow in the roentgenogram (Fig. 98). The nodules are distributed in miliary and uniform fashion. The lesions do not as a rule coalesce but may occasionally appear as conglomerate masses. There is no calcification or cavitation. The pleura is not involved.

Differential Diagnosis —The differential diagnosis is difficult and in ma instances impossible by roentgen methods Silicosis in the diffuse nodular ty may give an identical picture The nodules in silicosis are larger more de and are apt to involve the upper and mid lung fields without extensive involv ment of the peripheral and lower portions Coalescence and cavitation m occur The pleura is apt to be involved in silicosis Silicatosis occurs in talc powder workers and the picture may so closely simulate that in berylliosis th differential diagnosis is possible only if a history of exposure is establ h Siderosis occurs in iron workers and i characterized by massive fibrosis which entirely different from the changes in berylliosis In arc welders there is a nodul involvement of the lung but the nodules are unevenly distributed and do not i volve the entire lung field Enlargement of the hilar shadows and increase linear markings occur Inhalation of tin oxide produces miliary nodular shadow which are metallic in density and are not easily confused with the chan es i berylliosis In asbestosis the lesions are larger involve mainly the bases ha more associated linear density and produce more reaction in the diaphragmat pleura The presence of asbestos fibers in the sputum is important in diagno Byssinosis due to the inhalation of cotton dust bagassosis the result of inhalatio of waste du t from ugar cane and baritosis cannot be differentiated on th basis of the roentgen appearances and the differential diagnosis is depende on the hi tory and clinical findings The fungus diseases may produce doch imilar changes With actinomycosis the lesions are larger and irregul dı tributed Absce ses are commonly formed In aspergillosis there is a hi t of handling hay and grain and there is not the miliary or nodular den ity se in berylliosis Bla tomycosis shows a dense irregular shadow extendin fro the hilus toward the periphery and in the later stages often develops a diffuse or focal nodulation The di ease is seen in cattlemen and farmers The pulmo an lesions are larger and less uniformly distributed In coccidioidomycosis th acute type simulates pneumonia The prolonged or chronic form shows m lupl areas of involvement which are larger and more irregular although milia distribution may occur Cyst like cavities may persist in the cured case I histoplasmo is there is a disseminated fine nodular density throughout the lun The nodules are larger and show a central focus of calcification Moniliasis characterized by increa ed vascular markings and irregular masses which tend to involve particularly the lower lobes Nodular shadows may occur but a larger and more irregularly di tributed A yeast odor to the breath and positi culture from bronchoscopic drainage aid in diagno is Re ponse to potas iodide therapy is prompt Sporotrichosis produces lesions similar to tuberc with scattered densities and fibrosis

Toxoplasmosis develops as the result of exposure to rabbits squirrels do a birds and is characterized by den e hilar shadows with accentuated linear ma ings There are irregular areas of increased density in the bases but the pict r di fers from that in berylliosis Parrot fever or psittacosis is characterized by in creased linear densities and patchy infiltration of the bases There is no nodulat The rickettsial diseases typhus and Rocky Mountain spotted fever how more ex tensive pneumonic con olidations The primary atypical or viru pneumonia u ally shows a fan haped infiltration extending outward from the hila with ce nodulation or patchy areas of consolidation There may be diffuse nodular di p

sions but this form of the di case is less commonly seen In tularemia there is marked pleural involvement in association with the pulmonary lesions Passive congestion may cause a very closely similar picture in the chest roentgenogram particularly in the early stages of beryllium poisoning There is usually increased linear markings most marked in the middle thirds and at the bases Pleural effusion is common and the heart is enlarged Hemosiderosis in advanced mitral disease may produce diffuse and generalized nodular densities The heart picture usually makes the diagno is obvious In periarteritis nodosa there are nodules in the region of the walls of the small pulmonary vessels The lesions are most marked near the lung roots In Lœffler s syndrome transient pulmonary infiltrations may occur with soft areas or nodular densities in the lung somewhat similar to those in beryllìosis These are transient and disappear promptly Miliary tuberculosis may closely simulate beryllium poisoning The nodules are less uniform in size and distribution and are accompanied by linear fibrosis Malignant tumors the parenchymal type of Hodgkin s disease miliary carcinomatosis of the lungs and lymphangitic carcinoma due to diffuse penetration of the lymphatics and pleura may produce diffuse nodulation The picture is not exactly similar to that seen in beryllìosis Idiopathic pulmonary fibrosis is associated with granular and nodular shadows which extend throughout the lungs from the apices to the bases The density is linear in character and the nodules more variable in size The roentgen picture may be identical to that in chronic beryllìosis Erythema nodosum may have a picture similar to that of beryllìosis

The most important differential diagnosis concerns pulmonary sarcoidosis The form of sarcoidosis with enlarged hilar lymph nodes and large masses usually offers no difficulty The parenchymal forms closely simulate beryllìosis as there may be fine stippling throughout the lungs In sarcoidosis the disease is most marked in the central and lower thirds of the lung field whereas in early beryllìosis the changes are more uniformly distributed from apex to base and the linear density is absent or slight Coalescence of large masses so common in sarcoidosis may rarely occur in beryllìosis It must be stressed that the changes in sarcoidosis and beryllium poisoning may be almost exactly similar Remissions and regressions occur in both diseases but are more common in sarcoidosis Bone changes in sarcoidosis are helpful in differential diagnosis but in many instances these manifestations are not present Sarcoidosis is usually regressive and may di appear completely Beryllìosis has not been found to disappear once established

Therapy and Prognosis – The mortality in beryllio is approximates 20 per cent rising where the exposure and attack rates are higher Therapy is symptomatic and supportive With severe pulmonary insufficiency the most satisfactory treatment is the use of oxygen according to the requirements of the individual case The patient must limit exercise to the point of comfort Rest in bed and continuous oxygen therapy are necessary in the severe cases The most important factor is prophylaxis The concentration of beryllium in the air breathed by the workers must be kept at the lowest possible levels This may be done by the use of engineering control or personal protective devices Every person exposed to beryllium should have frequent roentgenograms of the chest The disease presents a very serious health hazard Every means to prevent the development of the disease in those exposed i absolutely e sential

Differential Diagnosis — The differential diagnosis is difficult and in many instances impossible by roentgen methods Silicosis in the diffuse nodular stage may give an identical picture The nodules in silicosis are larger more discrete and are apt to involve the upper and mid lung fields without extensive involvement of the peripheral and lower portions Coalescence and cavitation occur The pleura is apt to be involved in silicosis Silicatosis occurs in talc powder workers and the picture may so closely simulate that in beryllios[is] differential diagnosis is possible only if a history of exposure is established Siderosis occurs in iron workers and is characterized by massive fibrosis which is entirely different from the changes in beryllios[is] In arc welders there is a no[dular] involvement of the lung but the nodules are unevenly distributed and do not involve the entire lung field Enlargement of the hilar shadows and increased linear markings occur Inhalation of tin oxide produces miliary nodular sha[dows] which are metallic in density and are not easily confused with the chan[ges in] beryllios[is] In asbestosis the lesions are larger involve mainly the bases [with] more associated linear density and produce more reaction in the diaphragm [and] pleura The presence of asbestos fibers in the sputum is important in diag[nosis] Byssinosis is due to the inhalation of cotton dust bagassosis is the result of inhal[ation] of waste dust from sugar cane and baritosis cannot be differentiated on [the] basis of the roentgen appearances and the differential diagnosis is depe[ndent] on the history and clinical findings The fungus diseases may produce [somewhat] similar changes With actinomycosis the lesions are larger and irregu[larly] distributed Abscesses are commonly formed In aspergillosis there is a h[istory] of handling hay and grain and there is not the miliary or nodular density [seen] in berylliosis Blastomycosis shows a dense irregular shadow extending [from] the hilus toward the periphery and in the later stages often develops a diffu[se] focal nodulation The disease is seen in cattlemen and farmers The pulmo[nary] lesions are larger and less uniformly distributed In coccidioidomycosis [the] acute type simulates pneumonia The prolonged or chronic form shows mul[tiple] areas of involvement which are larger and more irregular althou[g]h mi[liary] distribution may occur Cyst like cavities may persist in the cured cases [In] histoplasmosis there is a disseminated fine nodular density throughout the l[ungs] The nodules are larger and show a central focus of calcification Monilia[sis is] characterized by increased vascular markings and irregular masses which [tend] to involve particularly the lower lobes Nodular shadows may occur but [are] larger and more irregularly distributed A yeast odor to the breath and po[sitive] culture from bronchoscopic drainage aid in diagnosis Response to potas[sium] iodide therapy is prompt Sporotrichosis produces lesions similar to tuberc[ulosis] with scattered densities and fibrosis

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sions but this form of the disease is less commonly seen. In tularemia there is marked pleural involvement in association with the pulmonary lesions. Passive congestion may cause a very closely similar picture in the chest roentgenogram particularly in the early stages of beryllium poisoning. There is usually increased linear markings most marked in the middle thirds and at the bases. Pleural effusion is common and the heart is enlarged. Hemosiderosis in advanced mitral disease may produce diffuse and generalized nodular densities. The heart picture usually makes the diagnosis obvious. In periarteritis nodosa there are nodules in the region of the walls of the small pulmonary vessels. The lesions are most marked near the lung roots. In Loeffler's syndrome transient pulmonary infiltrations may occur with soft areas or nodular densities in the lung somewhat similar to those in berylliosis. These are transient and disappear promptly. Miliary tuberculosis may closely simulate beryllium poisoning. The nodules are less uniform in size and distribution and are accompanied by linear fibrosis. Malignant tumors, the parenchymal type of Hodgkin's disease, miliary carcinomatosis of the lungs and lymphangitic carcinoma due to diffuse penetration of the lymphatics and pleura may produce diffuse nodulation. The picture is not exactly similar to that seen in berylliosis. Idiopathic pulmonary fibrosis is associated with granular and nodular shadows which extend throughout the lungs from the apices to the bases. The density is linear in character and the nodules more variable in size. The roentgen picture may be identical to that in chronic berylliosis. Erythema nodosum may have a picture similar to that of berylliosis.

The most important differential diagnosis concerns pulmonary sarcoidosis. The form of sarcoidosis with enlarged hilar lymph nodes and large masses usually offers no difficulty. The parenchymal forms closely simulate berylliosis as there may be fine stippling throughout the lungs. In sarcoidosis the disease is most marked in the central and lower thirds of the lung field whereas in early berylliosis the changes are more uniformly distributed from apex to base and the linear density is absent or slight. Coalescence of large masses so common in sarcoidosis may rarely occur in berylliosis. It must be stressed that the changes in sarcoidosis and beryllium poisoning may be almost exactly similar. Remissions and regressions occur in both diseases but are more common in sarcoidosis. Bone changes in sarcoidosis are helpful in differential diagnosis but in many instances these manifestations are not present. Sarcoidosis is usually regressive and may disappear completely. Berylliosis has not been found to disappear once established.

Therapy and Prognosis.—The mortality in berylliosis approximates 20 per cent, rising where the exposure and attack rates are higher. Therapy is symptomatic and supportive. With severe pulmonary insufficiency the most satisfactory treatment is the use of oxygen according to the requirements of the individual case. The patient must limit exercise to the point of comfort. Rest in bed and continuous oxygen therapy are necessary in the severe cases. The most important factor is prophylaxis. The concentration of beryllium in the air breathed by the workers must be kept at the lowest possible levels. This may be done by the use of engineering control or personal protective devices. Every person exposed to beryllium should have frequent roentgenograms of the chest. The disease presents a very serious health hazard. Every means to prevent the development of the disease in those exposed is absolutely essential.

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PULMONARY CYSTS

A. **Cystic Disease of the Lungs** (Figs 99-106)—Lung cysts may be congenital or acquired, single or multiple, and inflammatory or non inflammatory in origin. They arise in the bronchi or parenchyma and may contain gas, fluid or both. The multiple cysts occur in any portion of the lung and closely resemble bronchiectatic foci, producing numerous small, rounded, sharply defined areas of increased radiance within the lung. They may involve one or more lobes and are unilateral or bilateral. Fluid is at times present within the cysts. The solitary cysts are variable in size, occupying a portion of a lobe or an entire lung field. There is partial or complete absence of lung markings within the involved area. The margins of the lesion are dense, sharply defined, linear and smooth. There is compression of the lung adjacent to the margins of the cyst. When very large they depress the diaphragm and herniate through the mediastinum into the

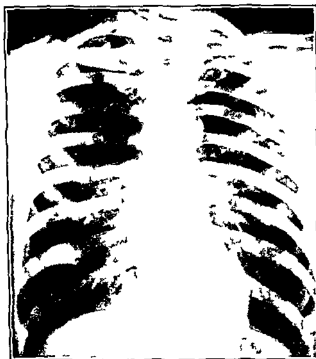


Fig. 99.—Pulmonary Cyst.

There is an ovoid area of increased radiance in the right apex and infraclavicular region extending to the level of the second interspace anteriorly. The margins of the area are sharply defined and there is complete absence of lung structure within it. There is no evidence of fluid in the cyst.

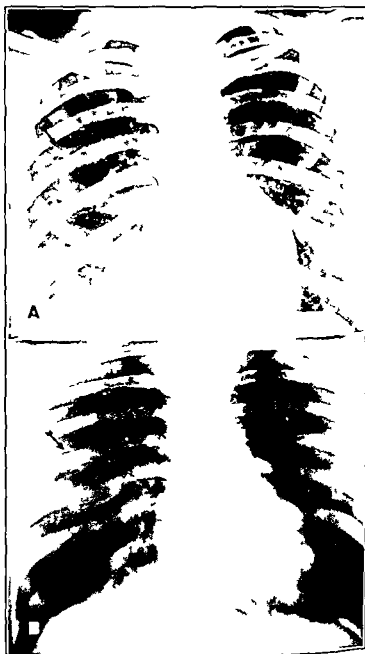


FIG 100 —Cyst in the Right Upper Lung Field Laminography

A Roentgenogram of the Chest There is an ovoid area of increased radiance with a dense margin in the right upper lung field at the level of the second and third ribs and (black arrow) The cyst is poorly visualized and its extent cannot be determined with accuracy

B Laminogram The cyst is clearly outlined Its wall is sharply defined and presents definite lobulations The size and character of the lesion are clearly delineated by laminography



Fig 101 —Cyst of the Lun

There is an ovo d area of increased radiance in the left upper lung field extending from the level of the fourth to the seventh ribs posteriorly a large cyst The margins of the cyst are sharply defined and smooth in outline Lung marking are isualized within this area indicating that the cyst does not extend completely through the lung There is a very small amount of fluid in the lower portion of the cyst



Fig 10? —Cyst ith Flu d

A There is a larg rounded area of increased radi n e in the paracardiac portion of the right m ddle and lower lung field The margins of the yst ar th n sharply defined and smooth in outline Lung markings are s ble through the yst The yst s fille l with air and contains no fluid at the time of this examinat on

B Lateral Projecti n One month later The yst i part lly filled with fluid and shows a horizontal fluid level (black arrow) The cyst is in the lower lobe

contralateral lung Fluid is in many instances present within the cyst resulting in a fluid level which shifts with change in the position of the patient but remaining horizontal at all times Linear strands of density within the cyst are common Lateral and oblique projections are essential in addition to the routine sagittal projections in order to localize the process An important point in the diagnosis of cyst(s) of the lung is the sharply defined margins of the lesion and the absence of reaction about its margins When the cyst is very large there is compression of the surrounding lung tissue Bronchographic studies may be of value in outlining the bronchus from which the condition originated As there is stenosis or absence of the bronchus the opaque medium demonstrates complete obstruction or marked narrowing of the bronchus at the site of the cyst

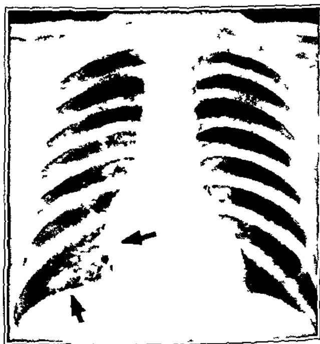


Fig 10 Congenital Cystic Disease

In the middle and lower thirds of the right lung field there is irregular mottled density with multiple small rounded sharply defined areas of increased radiance These are present thin walls The changes are characteristic of cystic disease of the lung The left lung field shows a mild degree of emphysema The heart and trachea are deviated slightly to the right indicating moderate atelectatic changes on the right side

The conditions which must be considered in differential diagnosis are emphysematous bleb lung abscess encapsulated empyema hydropneumothorax coccidioidomycosis and tuberculous cavities Emphysematous blebs occur in association with bronchiectasis and emphysema The margins of the bleb are very thin and linear in character There is partial or complete absence of the lung markings in the involved area When located at the base of the lung the diaphragm is flattened and depressed Fluid levels do not occur in blebs Lung abscess may be ruled out by the irregular reaction at the margins of the lesion In encapsulated empyema there

is pleural thickening the diaphragm may be elevated and the mediastinum is often retracted

B **Bronchiogenic Cysts** (Fig 10/)—Bronchiogenic cysts are most probably of congenital origin They occur usually in the mediastinum and probably also within the lung The cysts occurring within the lung however are acquired lesions and are considered sequelæ of bronchiectasis or lung abscess From a rœntgen point of view many of these lesions cannot be differentiated from lung



Fig 104—Congenital Bilateral Cystic Disease

There are multiple cysts of varying size throughout both lung fields with marked emphysema bilaterally The interspaces are widened the diaphragms depressed and flattened the costophrenic angles shallow and the heart vertical in position

abscess encapsulated empyema neurofibroma dermoids lymphoma malignant tumor aneurysm or an aberrant goiter The cysts do not produce symptoms and are usually incidental findings during examinations of the chest Many are found in survey studies of the chest which are being performed so widely at the present time They occur equally in males and females and are most commonly seen at or above the age of 40 When infected they simulate lung

abscess or empyema with a bronchial fistula both in symptomology and roentgen manifestations. Fluoroscopy is extremely important in the study of these cysts as it indicates the views best suited to demonstrate the location, size and nature of the mass. Roentgenoscopy also reveals attachment to the trachea or esophagus which may not be demonstrable otherwise. Sagittal, lateral and oblique views of the chest are necessary. Roentgenograms with the Bucky diaphragm and laminograms are extremely important in demonstrating these lesions. Barium studies of the esophagus are also valuable.

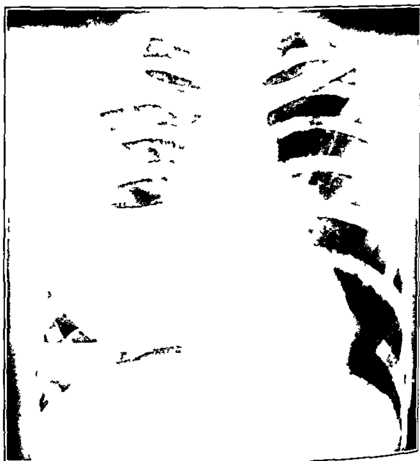


Fig. 10.—Bilocular Cyst with Fluid Levels

There is a large bilocular cyst occupying the middle and lower portions of the right lung field. The cyst is partially filled with fluid and fluid levels are demonstrable.

The cyst is visualized on the roentgenogram as a smooth round or oval shadow. It may occur anywhere within the mediastinum. There is no evidence of bone erosion or calcification. The presence of a mass lying beneath the carina with evidence of tracheal attachment is strong evidence in favor of the diagnosis of bronchiogenic cyst. They are frequently intramural and extramural in relation to the esophagus. These cysts frequently show a fluid level as the bronchus connects with the lesion. The presence of a fluid and air filled cavity in

cause confusion with lung abscess However there is much less inflammatory reaction in the lung than occurs with the usual abscess The wall of the cyst may be thin or thick and the cyst may alternately fill with fluid or drain and contain air In consequence there is a marked variation in the size of the shadows seen on subsequent roentgenograms In some instances there is a change in the shape of the mass with a shift in the position of the patient It may be impossible to demonstrate the exact location of the mass and the roentgenologist



Fig 106 —Multilocular Cyst of the Right Lung

A Sagittal projection There are multiple fluid levels in the right upper lung field The right apex and the upper and midportions of the lung field show increased radiance with absence of normal lung structure

B Lateral projection The cyst and the multiple fluid levels are clearly outlined The cyst is multilocular

C Lateral decubitus projection The fluid levels are visualized at the arrows

often cannot determine whether it is in the lung or the mediastinum The lesions are benign and surgical removal is not essential However operation is frequently undertaken for definite diagnosis and to exclude the possibility of neoplasm of the lung

C **Mediastinal Cysts** —These are either dermoids or teratomas and are discussed under lesions of the mediastinum

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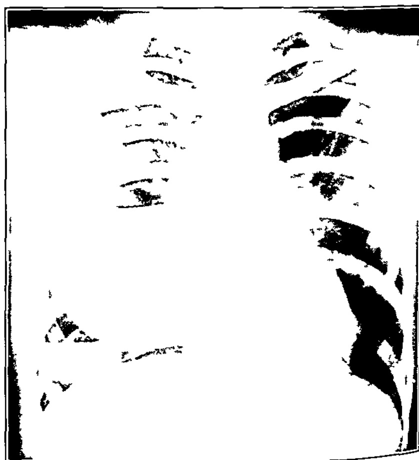


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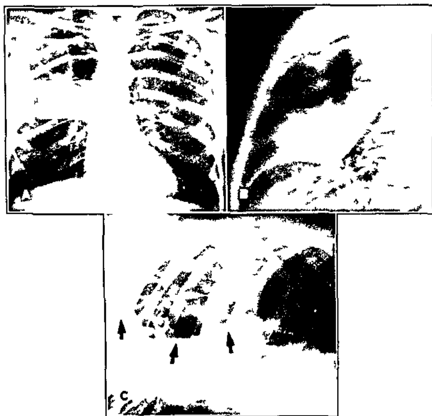


FIG 106 —Multilocular Cyst of the Right Lung

A Sagittal projection There are multiple fluid levels in the right upper lung field The right apex and the upper and midportions of the lung field show increased radiance with absence of normal lung structure

B Lateral projection The cyst and the multiple fluid levels are clearly outlined The cyst is trilocular

C Lateral decubitus projection The fluid levels are visualized at the arrows

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C **Mediastinal Cysts** —These are either dermoids or teratomas and are discussed under lesions of the mediastinum

Hydatid Cysts Pulmonary hydatid cysts are visualized as round homogeneous areas of increased density within the parenchyma of the lung The inter spaces are widened and the ribs usually are obliterated by the shadow of the cyst Calcification may occur but is rare The movements of the diaphragm may be limited if the mass is large and occupies the base of the lung As the

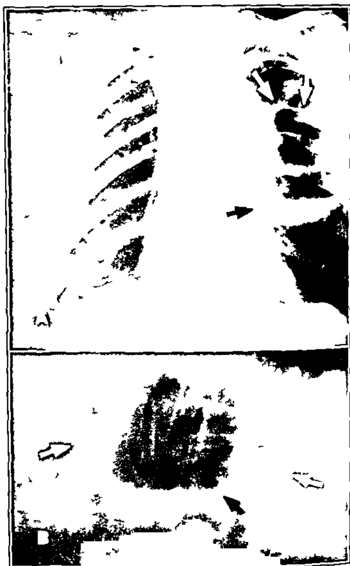


Fig 107 — Bronchiogenic Cyst

A Sagittal projection There is a large cyst occupying the middle third of the left lung field The margin of the cyst form a linear band of increased density which is sharply defined and smooth in outline (white arrows) There is a fluid level in the lower pole of the cyst (black arrow) The trachea is deviated markedly to the right

B Decubitus projection patient prone the film at the patient's left side and the roentgen rays directed horizontally through the thorax The margins of the cyst (white arrows) are more clearly outlined than in the conventional roentgenogram There is a fluid level in the dependent portion of the cyst (black arrow)

lesion enlarges there may develop fibrous lines radiating into the surrounding parenchyma which obscure the contours of the mass The presence of calcified cysts elsewhere in the body particularly in the liver is of importance in diagnosis Bronchographic studies produce a characteristic picture in many instances the bronchi being displaced and compressed When the cysts are filled with fluid they may change in size and density on inspiration and with shift in position of the patient The small multiple type closely simulate metastatic neoplasm However if one or more of the shadows show a fluid level the diagnosis may be made with a fair degree of certainty Rupture of hydatid cyst of the lung produces cystic emphysema with a crescentic area of increased radiance which corresponds to the accumulation of gas in the region of the cyst walls In some instances rupture is followed by widespread inflammation and atelectasis Fluid levels and air pockets may occur and are very important in diagnosis

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PULMONARY NEOPLASMS

Tumors of the lung, both primary and metastatic, have shown a marked increase in frequency in recent years. The reasons for this are not entirely clea although numerous factors which appear to be of importance in this regard are becoming more clearly understood. Roentgen examination occupies a positi of prime importance in diagnosis and localization as well as in study of the progress of the neoplastic process and observation of the efficacy of therapeutic measures. It is of the utmost importance to closely correlate the clinical roent gen and bronchoscopic observations in order to arrive at as early and accurate a diagnosis as possible. The roentgenologist must avail himself fully of every a at his command as the roentgen findings are frequently the first and most impor tant factors in contributing to early diagnosis. Sagittal roentgenogram be t made stereoscopically must be supplemented by lateral oblique and decubitu projections. Fluoroscopy is absolutely essential. Bronchography and body section roentgenography may supply valuable data. Overexposed films with the Bucky diaphragm are very important to visualize lesions behind the heart and for observation of the bony structures. Roentgenograms in full expiration in addition to those usually made at the end of inspiration may be helpful to demon strate areas of localized emphysema or atelectasis. Repeated examinations a intervals of a few days or weeks to show the progression of the changes may be very important in arriving at a final conclusion. Studies of the bony thorax may demonstrate destructive changes in the osseous structures and assist in establishing the nature of the lesion. Search for a primary focus in suspected metastatic tumors of the lung may entail roentgenography of the bony skeleton urinary tract, gastro-intestinal organs, skull and other regions. The neopla of the lung which may be encountered include 1) primary carcinoma of the lung, 2) metastatic neoplasms, 3) benign tumors such as adenomas, cysts d hamartomas. Pleural neoplasms, mediastinal tumors and tumors of the chest wall and bony thorax are discussed separately elsewhere.

BRONCHIOGENIC CARCINOMA

Bronchiogenic carcinoma is one of the most common types of malignanc and comprises approximately 5 to 10 per cent of malignant tumors. It is gener ally agreed that there has been a marked rise in the incidence of the disease in the past 50 years. Autopsy studies throughout the world indicate a great in crease in the incidence of bronchiogenic carcinoma in relation to cancer in general. Statistics compiled both in this country and abroad offer defi evidence that the number of deaths from carcinoma of the lung is becomi greater. In 1925 the mortality rate of cancer of the lung and pleura was approx mately 2.19 per 100,000 population in the United States. The year 1947 showed a mortality of 6.7 per 100,000 for the same disease. Statistical studies show that it is now the most frequent visceral carcinoma in men. The reasons for this i crea

are not clear Many observers believe that an important factor is the increased exposure to irritating inhalations such as tobacco smoke coal tar derivatives and various types of dust There is evidence that smoking and more particularly the smoking of cigarets is the important factor In recent studies by Wynder and Graham and Levin Goldstein and Gerhardt there are definite indications of a causal relation between smoking and carcinoma of the lung Because of the far reaching importance of these studies the conclusions of these authors will be given in full Wynder and Graham state as follows Excessive and prolonged use of tobacco especially cigarets seems to be an important factor in the induction of bronchiogenic carcinoma Among 605 men with bronchiogenic carcinoma other than adenocarcinoma 96 5 per cent were moderately heavy to chain smokers for many years compared with 73 7 per cent among the general male hospital population without cancer Among the cancer group 51 2 per cent

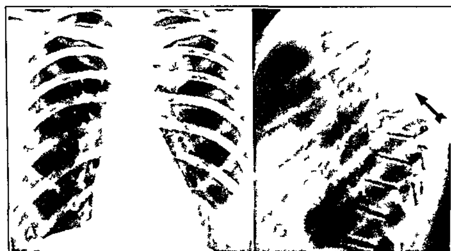


Fig 108 —Bronchiogenic Carcinoma

A Sagittal projection A rounded mass is visualized in the left upper lung field in the region adjacent to the aortic knob

B Lateral projection The tumor is in the posterior third of the lung field and is partially obscured by the shadow of the spine (black arrow)

were excessive or chain smokers compared to 19 1 per cent in the general hospital group without cancer The occurrence of carcinoma of the lung in a male non smoker or minimal smoker is a rare phenomenon (2 0 per cent) Tobacco seems at this time to play a similar but somewhat less evident role in the induction of epidermoid and undifferentiated carcinoma in women Among this group a greater percentage of nonsmokers will be found than among the men with 10 of 25 being nonsmokers Ninety six and one tenth per cent of patients with cancer of the lungs who had a history of smoking had smoked for over 20 years Few women have smoked for such a length of time and this is believed to be one of the reasons for the greater incidence of the disease among men today There may be a lag period of 10 years or more between the cessation of smoking tobacco and the occurrence of clinical symptoms of cancer Ninety four and one tenth

per cent of male patients with cancer of the lungs were found to be cigaret smokers 4 0 per cent pipe smokers and 3 5 per cent cigar smokers This preva lence of cigaret smoking is greater than among the general hospital populatio of the same age group The greater practice of inhalation among cigaret smoke is believed to be a factor in the increa ed incidence of the disease The influence of tobacco on the development of adenocarcinoma seems much less than on th other types of bronchiogenic carcinoma Three independent studies have resulted in data so uniform that one may deduce the same conclusions fro each of them

The conclusions of Levin and his co workers are In a hospital populatio cancer of the lung occurs more than twice as frequently among tho e who ha e



Fig 109 —Primary Carcinoma of the Lung

There is an area of increased density in the paravertebral portion of the ri ht upper lun field The margins of the are are irregular and poorly defined The ri ht hilus shad w is incr ased in width and d nsity There is diffuse mottling and decreased radian e thr u h out the right lung field The heart and mediastinal contents are deviated to the ri ht th interspaces on the right side are markedly narrowed and the right lung is decreased in e indicati e of atele tasi There i evidence of localized hyperæration of the ri ht mid l field in the region about the hilum distal to the tumor The left lung sho s compen ator emphysema

smoked cigarets for twenty five years than among other smokers or non sm ker of a comparable age Pipe smokers apparently experience an almo t equal in crease of the incidence of lip cancer compared with other smokers or non smoke It is somewhat surprising to find that the type of smoking re cigaret f lung cancer pipe for lip cancer is the associated factor rather than the act use of tobacco The data uggest although they do not e tabli h a ca s

relation between cigaret and pipe smoking and cancer of the lung and lip respectively. The statistical association may of course be due to some other unidentified common factor between these types of smoking and lung and lip cancer. Cancer is now generally considered a disease attributable to multiple causative factors. Among these are irritants. The generalization has been advanced that although not all irritants are carcinogenic, all carcinogens are irritants, that is capable of inducing chronic reparative hyperplasia. Berenblum has shown also that an irritant (cotton resin basic tar fraction) which is non

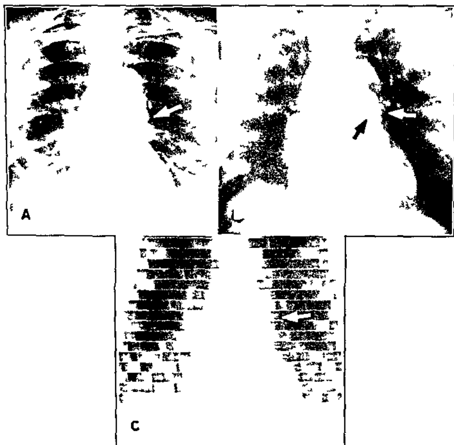


Fig. 110.—Bronchiogenic Carcinoma

A Sagittal roentgenogram. There is a rounded area of density in the region of the left lung root. The margins of the mass are sharply defined and appear slightly lobulated (white arrow).

B Laminogram. The area of density at the left lung root is more clearly visualized than in the routine roentgenogram of the chest (white arrow). The trachea is deviated to the right and appears narrowed. The right main bronchus is clearly visualized. The main bronchus on the left is narrowed (black arrow).

C Kymograph. The mass at the left lung root shows a transmitted type of pulsation with short blunt pulsation (white arrow). Operation revealed a bronchiogenic carcinoma at the left lung root.

carcinogenic alone may nevertheless increase the percentage of tumors produced when its action is combined with that of a carcinogen Thus some experimental basis exists for explaining the apparent effect of cigaret and pipe smoking although the true nature of the association with lung and lip cancer remains to be determined

It is of interest to note that silicosis and pneumonoconiosis apparently play no important role in this respect although the proportion of smokers in these diseases is very high Tuberculosis which was formerly considered the etiologic factor now appears to be of diminishing importance Trauma is not apparently

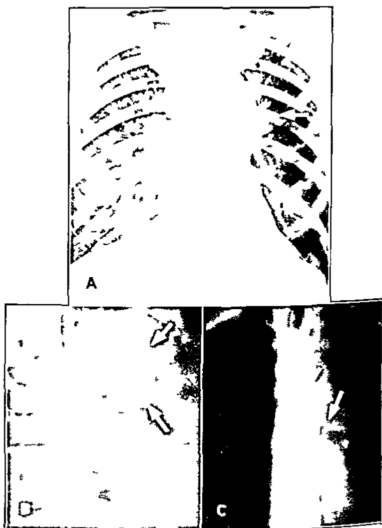


FIG 111 — Bronchiogenic Carcinoma Left Lung Root

A Sagittal roentgenogram of the chest There is a rounded area of increased density at the left hilum (white arrow) The margins of the mass are irregular and poorly defined

B Lateral roentgenogram of the chest The tumor lies in the mid portion of the left lung field adjacent to the hilum

C Laminogram at 7 cm The left main bronchus is clearly outlined (white arrow) and appears narrowed

a causative factor except in very rare instances The disease is widely distributed at all ages with the highest incidence from 40 to 60 years Cases have been reported in infants and children and also in the aged There is a great predominance in males the ratio being approximately 5 to 1

Bronchiogenic carcinoma today stands second only to carcinoma of the stomach as a cause of cancer death in the male Cure is possible only if the lesion is

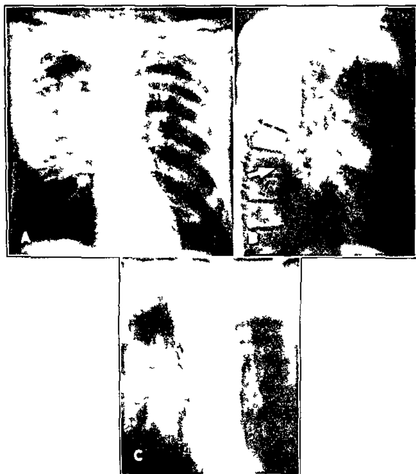


Fig 11? – Carcinoma of the Lung

A Roentgenogram of the chest There is an irregular area of mottled density in the right lung field extending from the level of the second to the fourth ribs anteriorly The margins of the area of density are irregular and poorly defined

B Lateral roentgenogram of the chest The area of density occupies the lower portion of the right upper lobe (white arrow)

C Laminogram Depth 10 cm The trachea is deviated markedly to the right There is occlusion of the right upper lobe bronchus (white arrow) There is extensive atelectasis with multiple small areas of emphysema in the lower portion of the right upper lobe Bronchoscopy revealed carcinoma involving the right upper lobe with occlusion of the bronchus



Fig 122 —Carcinoma of the Lungs Superior Sulcus Tumor Venography
The patient complained of pain in the chest and cough There was a Horner s syndrome There is a triangular area of increased density occupying the upper third of the right lung field The trachea is slightly narrowed The heart is deviated to the right Venography on the left side showed dilatation and tortuosity of the veins with obstruction of the subclavian vein At operation a Pancoast tumor was found in the right upper lung



Fig 123 —Tumor of the Lung Adenoacanthoma
A Roentgenogram of the chest There is a smooth rounded sharply defined area of increased density in the right lung field extending from the fourth to the eighth ribs posteriorly
B Laminography The area of density in the right lung field is more clearly outlined The heart and trachea are deviated to the right the right interspaces are narrowed and the right side of the chest is smaller than the left indicative of atelectasis
Operation revealed an adenoacanthoma of the lung

produce localized destruction of the ribs and is associated with the presence of a Horner's syndrome in many instances In the Pancoast type of tumor there is a homogeneous density involving the apex and the upper third of the lung field with destruction of a portion of one or more ribs (Fig 121) In contrast to the other types of bronchiogenic carcinoma the apical lesions frequently produce very striking and severe clinical manifestations which are in marked contrast to the relatively small size of the neoplasm Because of involvement of the pleura pleural effusion frequently develops in this type of tumor The fluid is apt to be bloody

The size of the tumor in primary carcinoma of the lung may vary from miliary to extremely large The mass may be rounded irregular or wedge shaped With the passage of time the tumors enlarge both centrally and peripherally In some instances there is a narrow band of density extending from the mass in the lung to the hilum The hilus nodes are usually not involved until late in the parenchymal types of primary carcinoma and the same is true of the peripheral type The neoplasm may in some cases be manifested as a nodular dissemination or a diffuse reticulation in the lung rather than as a localized mass Abscess formation is usually due to perforation of the bronchial walls with subsequent necrosis Lobar consolidation may precede or accompany the abscess formation

Fluid is of frequent occurrence in tumors of the lung and in many cases obscures both the primary growth and areas of destruction in the bony thorax Marked thickening of the pleura is also common and may simulate pleural effusion both clinically and roentgenographically The displacement of the mediastinal structures and the changes in the bony thorax which occur in fluid or atelectasis may be modified or absent in the presence of marked infiltrations or thickening of the pleura Bronchiectasis is a frequent concomitant of primary carcinoma of the lung Pneumonitis unresolved pneumonia and chronic tuberculosis may be associated with primary carcinoma of the lungs and may mask or obscure the clinical and roentgen picture for long periods of time Elevation of the diaphragm with paradoxical excursion is indicative of paralysis of the phrenic nerve by invasion of the neoplasm Metastases may occur to the same or opposite lung hence the fact that there are multiple tumors in the lungs does not exclude the possibility of bronchiogenic carcinoma

Bronchography is of great value in demonstrating bronchial occlusions abscess formations and bronchiectatic changes Body section roentgenography and overexposed films with the Bucky diaphragm are of aid in the demonstration of narrowing or obliteration of the bronchus cavitations and changes in the ribs scapulæ clavicles or vertebræ as well as lesions which may be obscured by the overlying heart or mediastinal shadows (Fig 111) Therapeutic pneumothorax particularly after withdrawal of pleural fluid may outline masses which are obscured and also show other important changes which otherwise might not be demonstrable Roentgen kymography is of great value in differentiating tumors from aneurysms of the aorta and great vessels (Figs 110 114) Roentgenoscopy is particularly important in the diagnosis of early tumors of the lung and must be utilized in every case Laminographic studies are especially indicated to show changes in the bronchus and to demonstrate masses which otherwise would be overlooked or obscured (Figs 111 114) It is essential that the radiologist and clinician avail themselves of every diagnostic procedure as only in this way can early and accurate diagnosis be established It is ob

viously of the utmost importance that the lesion be diagnosed early if there is to be any hope of cure Serial roentgenograms at intervals of a few days or weeks to demonstrate the progression constitute a most important aid in dia nosis However it is not advisable to wait more than 2 or at mo t 3 week between the examinations as longer intervals may permit of marked extension of the tumor and the development of metastases (Fig 117)

The differential diagnosis must include a great host of lesions Tuberculosi bronchiectasis pneumonia lymphoma, metastatic neoplasm post radiation fibrosis and many other conditions must be considered Lipoid pneumonia the virus types of pneumonia and the non specific granulomas may produce changes which closely simulate primary carcinoma of the lung Lung absce associated with homolateral displacement of the heart and mediastinal contents or localized emphysema distal to the abscess should always raise the question of bronchiogenic carcinoma Syphilis and tuberculosis may closely simulate carci- noma of the lung The tuberculoma which produces a solitary mass in the lung quite similar in appearance to carcinoma of the lung is usually considered a benign lesion However all tuberculomas are potentially dangerous because of the great probability of subsequent breakdown with the dissemination of tubercle bacilli This results in rapid and widespread dissemination of the disease

The principal benign tumors which may cau e confusion in diagnosis are the lipomas neurofibromas chondromas adenomas hamartomas and cy t These lesions do not show rapid progression on subsequent roentgen studie The laboratory examinations are also negative Several vascular types of le ior are occasionally confused with carcinoma An infarct may produce an area of density in the lung which simulates carcinoma The history is usually importa t and establishes the differential diagnosis Studies after an interval of one or two weeks show resolution and diminution in the size of the infarct A bronch olith due to a foreign body may produce bronchostenosis with atelectasis Sub- sternal thyroid may be differentiated by the displacement and narrowin of the trachea which usually occurs in this condition Metastatic lesions may in rare instances be solitary and sharply defined and produce pictures which n closely simulate primary carcinoma of the lung The determination of the primary site of the growth is usually the important factor in establishin the diagnosis

As stated previously it must constantly be borne in mind that other diseases particularly tuberculosis and pneumonia can occur simultaneously with a bronch iogenic carcinoma and the establishment of one diagnosis does not preclude th presence of tumor Bronchiogenic carcinoma may so closely mimic many othe diseases that diagnosis is difficult With the recent advances in surgical techni the importance of early and accurate diagnosis has become greatly empha ized and it is of the utmost importance to establish the diagnosis early if the mortality is to be lessened The use of every diagnostic aid to the fullest pos ible exte t is essential The possibility of carcinoma of the lung must be borne in mind i every obscure pulmonary lesion Only by constant care and alertness will ea y diagnosis be po sible

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METASTATIC TUMORS OF THE LUNGS

Metastatic tumors of the lungs may be demonstrable relatively early by roentgen methods although it is a well known and generally accepted fact that they may be present for considerable periods of time without giving rise to clinical manifestations of their presence In many instances metastases in the



Fig 124 Advanced Metastatic Carcinoma

There are multiple nodules of varying size scattered diffusely throughout both lung fields The nodules are sharply defined and in any present irregular margins The primary site was a carcinoma of the recto sigmoid

lung are found long before the primary growth has been discovered empha iz the importance of routine roentgen studies and mass surveys of the chest Th metastatic lesion may originate either in the lung itself or from distant organ Neoplasms of the mediastinum and subphrenic regions may invade the lung b direct extension The lung serves as a filter because of its abundant capillar supply and the metastatic lesions reach the pulmonary field by way of th lymphatics and both the lesser and greater circulations In some in tances th site of the primary growth may be determined with a fair degree of certa t by the character of the metastatic foci in the lung Concomitant lesions in th

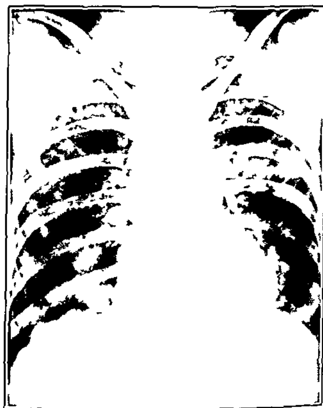


Fig 17 Ad mantinoma of the Maxilla with Pulmonary Metastases

There re multiple rounded areas of increased density scattered irregularly throu h both lung fields The metastatic nodules vary widely in si e shape and distribution Th primary site was an adamantinoma of the left maxilla

ribs clavicles humeri or scapulæ may be of great importance in arriving at a diagnosis and the bony structures as well as the lungs mediastinum and dia phragms must be carefully observed in all instances Primary sarcoma rarel if ever metastasizes to the bone but does show a high incidence of pulmonar metastases Metastatic sarcoma which is of the slow growing variety may in rare instances show calcific deposits within the pulmonary metastases (Fig 1 Carcinoma of the breast tends to spread to the lungs and mediastinum in many stances in ome cases relatively early The most common sources of meta ta lesions in the lungs are the breast kidney thyroid and the bones



FIG 176 — Metastatic Sarcoma

There are numerous rounded areas of increased density scattered irregularly throughout the lung field. Some of the masses are coalescent and lobulated.



FIG 177 — Metastatic Melanotic Neoplasm

There is a solitary metastasis in the right infraclavicular region. The tumor is sharply defined and smooth in outline. The melanotic tumors are highly malignant.

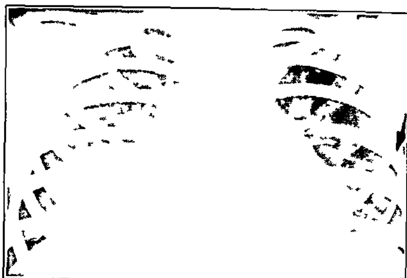


Fig 132 —Neuroblastoma

There is a large rounded soft tissue density occupying the lower third of the right lung field in the region above the diaphragm and adjacent to the border of the heart There is a metastatic nodule at the left base at the level of the fourth interspace anteriorly (arrow)

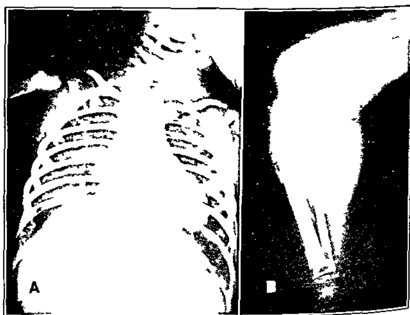


Fig 133 —Neuroblastoma

A Chest There is a large rounded area of density in the right lower lung field Smaller nodules are present in the right upper and left mid lung field There are nodular rounded soft tissue masses at the hila The soft tissues of the axillas are increased in density and thickness

B Leg There are destructive changes in the upper and lower thirds of the shaft of the tibia and periosteal elevation in the region of the mid shaft Similar changes are present in the lower third of the diaphysis of the femur The soft tissues of the thigh and the upper portion of the lower leg are markedly thickened and swollen Pathologic examination revealed neuroblastoma with metastases to the lungs

Differential Diagnosis — The differential diagnosis of metastatic carcinoma of the lung is difficult and in many instances may be impossible by roentgen methods alone The finding of a primary source or the knowledge that the patient has a malignant neoplasm elsewhere in the body is important It must be borne in mind that metastases from carcinoma of the breast and other organs may not develop until the lapse of an interval of many years after the original tumor has been removed surgically or by other methods It is not uncommon for a carcinoma of the breast to remain latent and develop metastases after an interval of 5 10 or more years



FIG 134 —Pulmonary Metastases from Wilms Tumor
The patient had a large mass in the right side of the abdomen which was proven at operation to be a Wilms tumor There are multiple metastases in both lungs [illegible]

In sarcomatous lesions the masses in the chest are usually rounded clearly demarcated and sharply defined Hypernephroma metastases tend to be lobulated Sarcoma of the bone is usually associated with homogeneous masses and the osteogenic types produce slow growing foci which in rare instances may show actual calcifications within the pulmonary metastatic foci (Fig 130) Tumors of the thyroid tend to produce multiple round smooth masses in the lungs

Miliary tuberculosis congestion and edema pneumonoconiosis sarcoidosis pulmonary fibrosis bronchiectasis virus pneumonia diaphragmatic hernia and a host of other condition must be considered in the differential diagnosis The response to radiation therapy after failure of improvement with antibiotic and other clinical therapeutic measures may be of assistance in establishing the diagnosis of pulmonary metastases Secondary inflammation and abscess formation occur only rarely in or about the metastatic lesions An important point in differential diagnosis is that atelectasis is seldom seen in association with metastatic carcinoma Serial roentgen studies at intervals of a few weeks usually show

rapid and regular increase in the number and size of the malignant lesions The together with the development of new foci in the mediastinum and the br thorax helps make the diagnosis clear The determination of the primary foc is one of the most important factors Response to radiation and other form o therapy may be helpful in some instances In many cases the postmorte findings must be awaited in order to establish the diagnosis with definitene s

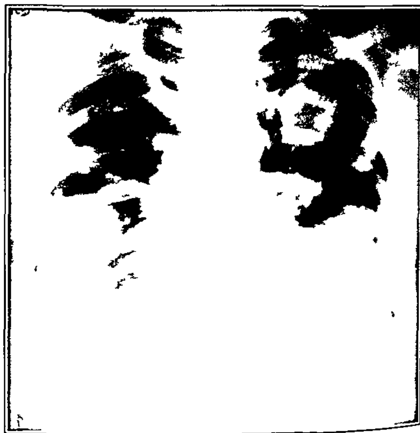


Fig 15 —Metastatic Choriocarcinoma and Epidermoid Cysts
There ar multiple r unded nodules of increased density scattered irre ularly throu hout both lung fields The masses in the lung fields are choriomatous nodules and epiderm l cysts secondary to a teratoma testis

Accuracy of Roentgen Diagnosis —The accuracy and efficiency of the roent en examination in the demonstration of nodular types of metastatic lesion is ver high In practically every case the roentgenogram permits of vi ualization of the lesion prior to the development of physical signs or symptoms Le ion a small as 3 to 5 mm can be visualized on properly executed roentgenogram al though much larger densities may be obscured by overlying ribs or other sha i if reliance is placed on the single sagittal film or a survey study Milian type of metasta es particularly if less than 3 mm in size cannot be visualized by roen methods A single roentgenogram if negative cannot be accepted as definite ev dence that metastatic disease does not exist The studies must be repeated at

cated before a final conclusion is reached In every instance a careful correlation of the clinical facts is essential if the patient is to receive the maximum benefit from the roentgen studies

Chorion Epithelioma —Metastatic chorion epithelioma in the lung is a rare condition and is usually confused with tuberculosis or pneumonia The rate of progression of the growth is very rapid Metastases may also take place to the bones liver brain and kidney While the disease is usually seen in females it occurs in males in teratoma of the testis and has also been found to originate in dermoid cysts Roentgen examination of the chest shows multiple nodules which are rounded sharply defined and widely distributed on one or both sides (Figs 135 136) They closely resemble sarcomatous metastases However the margins of the lesions in some areas are less sharply defined than the sarcomatous tumors

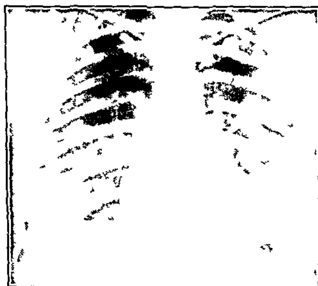


Fig 136 – Metastatic Chorioni Carcinoma

There is diffuse infiltration with multiple irregular masses in both lower lung fields more on the left The diaphragms and costophrenic angles are hazy The primary source was a chorionic carcinoma The masses increased rapidly in size density and number The lesion did not respond to x ray therapy

and in many instances the malignant nodules may be imbedded in a lobulated infiltration In addition to the lesions above described there may be small miliary type nodules and less commonly the disease may assume a diffuse pneumonic form Mediastinal masses often occur and also a pleural effusion which on tap is found to be hemorrhagic The diagnosis must be definitely considered if in association with the above described changes there is a mediastinal tumor or a large testicle in a male and a recent history of a pathological pregnancy or abortion in the female The diagnosis may usually be confirmed by hormone tests

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terized by marked changes in the lymphoid tissues the findings in any organ or portion of the body depend on the location and amount of lymphatic tissue and the degree to which it is affected In the mediastinum there are multiple collections of lymph nodes in both the anterior and posterior divisions Numerous nodes extend along the trachea termed the paratracheal group the tracheobronchial glands occur at the hila the bifurcation of the trachea and about the major bronchi and the bronchopulmonary lymphatic glands lie at the angles of the bronchial branches Discrete or generalized enlargement of some or all of these groups of glands may occur The mediastinal glands may be increased in width and density with sharply defined lobulated margins The involvement may be unilateral or bilateral The trachea may be compressed or deviated



Fig 140 —Lymphosarcoma
There is a large rounded mass in the lower third of the left lung field in the region above the diaphragm The mass overlies the shadow of the heart The hilus shadows are moderately prominent The soft tissues of the neck are increased in width and density on both sides more on the right Pathologic findings lymphosarcoma

Pulmonary lesions may be due to direct extension of the process from the involved lymphatic glands This invasion occurs in the form of a solid growth extending across the mediastinal pleura into the parenchyma of the lung to produce a massive tumor A second mode of extension is by infiltration of the disease along the peribronchial and perivascular lymphatics with a resultant granulomatous bronchitis and peribronchitis The bronchi may be encircled by masses of granulomatous tissue Multiple feathery or linear areas of increased density extend from the hila into the lung fields Occlusion of the bronchi take place with resultant patches of atelectasis Extension through the alveoli produces consolidation of a lobe or lobes Nodules of varying size may occur as single or multiple discrete sharply defined areas of density in the parahilar region or scattered through the lung fields

While cavitation is not a common feature in the lymphomas it has been observed in many instances The cavities vary from small foci of central necrosis to extremely large areas of radiance involving a considerable portion of the lung Purulent expectorations and hemoptysis occur at this stage of the disease Tracheobronchial fistula may develop adding to the difficulties of diagnosis Pleural involvement is manifested by nodular or infiltrating masses on the pleural surfaces and massive pleural effusions Fluid can be caused by pressure of the enlarged mediastinal lymph nodes on the lymphatics and blood vessels of the hilum without direct involvement of the pleura

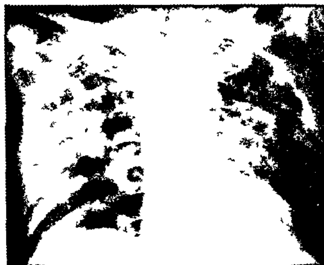


Fig 141 —Leukemic Infiltration of the Lung

There is extensive mottling throughout both lung fields more on the right The supracardiac area is increased in width bilaterally due to enlarged mediastinal glands The changes are due to leukemic infiltration of the lungs in a patient with chronic myelogenous leukemia

Any or all of the bones of the thorax may be involved by direct extension from the underlying lymph nodes the lung or the pleura The changes are very variable and consist of localized areas of bone destruction or diffuse generalized osteosclerosis In rare instances the process apparently starts in the ribs or sternum and invades the lungs

The heart may be involved by direct extension from adjacent structures particularly *the neighboring mediastinal lymph nodes In a case previously* reported by us there was involvement of the pericardium and invasion of the heart a mass projecting into the right auricular cavity The relatively small amounts of lymphoid tissue in the heart is doubtless an important factor in the rarity of cardiac involvement Extension to the pericardium can also take place by retrograde invasion along the lymphatics or the blood stream

It is generally recognized that the lesions in Hodgkin s disease may undergo malignant degeneration with the formation of sarcoma The disease is usually widely disseminated and progressive though remissions may occur In some instances the lesions are clinically silent giving no physical evidences of their

on bronchoscopic and histopathologic examinations Fluoroscopic studies a roentgenograms during forced expiration may aid in discovering obstructive em physema and should be utilized whenever partial bronchial obstruction is suspected Body section roentgenography and Bucky diaphragm films are importar and may demonstrate the tumors in some cases Bronchography is of value a it shows the site of the tumor or the obstruction in the bronchus It is particularly useful when bronchoscopy has failed and is also important in demon strating the presence of bronchiectasis or other changes distal to the adenoma In some instances the bronchoscopist may remove a portion of the tumor Bronchial adenoma should be considered a diagnostic possibility in the youn



FIG 143 —Bronchial Adenoma

A February 14 1940 There is a rounded sharply defined area of increased density in the right lung field adjacent to the inferior margin of the right hilum (white arrow)

B Anteroposterior projection May 22 1944 The mass at the right hilum is slightly larger and denser There is irregular mottling involving the lower third of the right lung field with deviation of the heart and trachea to the right due to atelectasis and pneumonic consolidation

C Lateral projection May 22 1944 The mass in the right paracardiac region is localized at the white arrow There is marked atelectasis of the right lower lobe

D February 28 1945 The mass has increased in size and the atelectasis is more marked







Fig. 143 (Continued)

E Bronchogram February 28, 1945. There is complete obstruction of the right lower lobe bronchus (black arrow).

F Photograph of the resected lung. The neoplasm is visualized at the white arrow.

G Roentgenogram of the resected lung. The white arrow indicates the tumor.

At operation an intrabronchial adenoma of the right lower lobe was found and pneumonectomy was performed. Microscopic Report: Bronchogenic adenoma with transition into malignancy (adenocarcinoma).

cough and hemoptysis have been reported The condition occurs at any a[illegible] but is most common in the fourth decade Both sexes are affected equally More cases are being recorded each year and the roentgenologist should be abl[illegible] to make the diagnosis in many instances The lesion is usually sharply define[illegible] smooth in outline and rounded or lobulated (Figs 144 145) Normal lun[illegible] is present about the tumor Small calcific deposits may be scattered irregula[illegible] through the mass *The presence of flecks of calcification should definitely lea[illegible] one to think of the diagnosis* The condition is usually mistaken for a cyst o[illegible] the echinococcus type However these cysts calcify by a thin rim of calcificati[illegible] around the periphery and not within the tumor itself The larger hamartoma[illegible] without calcification may very closely simulate metastatic nodules primar[illegible]

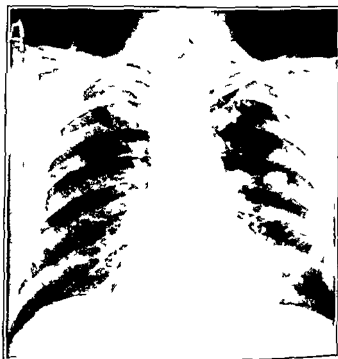


FIG 145 —Hamartoma

There is an ovoid slightly lobulated area of increased density in the left upper lun[illegible] fiel[illegible] The margins of the area are sharply defined and smooth in outline Numerous small calc[illegible] deposits are scattered irregularly throughout the mass

lung tumor neurofibroma encapsulated fluid and cysts of other types Ane[illegible] rysms of the aorta teratomas and dermoid cysts offer less difficulty in diagno[illegible] as they usually lie close to the mediastinum while the *hamartoma* is within th[illegible] lung itself either at the periphery or centrally A Ghon tubercle can ver[illegible] closely simulate a hamartoma [4] A small hamartoma situated in the bronch[illegible] may produce occlusion with atelectasis leading to a diagnosis of adeno carcinom[illegible] of the lung Pulmonary abscess has also been confused with hamartoma Whe[illegible] these tumors *lie adjacent to the hilum* they are very apt to be mistaken f[illegible] tuberculosis or central pneumonia Hemangioma must also be excluded in th[illegible] differential diagnosis Hemangioma can be diagnosed with a reasonable degre[illegible]

of certainty in some instances by the Valsalva maneuver the tumor becoming distinctly smaller when the patient inspires and strains while holding the breath The chief importance of the condition is that it is benign and the prognosis is good They can be removed surgically and numerous case have been treated successfully

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PULMONARY INFARCTION AND EMBOLISM PULMONARY CONGESTION—UREMIC EDEMA OF THE LUNGS—BLAST INJURIES

PULMONARY INFARCATION AND EMBOLISM

Pulmonary Infarcation (Figs 146–150) —Occlusion of a main branch of the pulmonary artery almost always results fatally If a smaller vessel is involved, infarcation usually develops the extent of the changes varying with the size of the artery affected the number of emboli and other factors Infarcts vary in size from a small area measuring only a few millimeters in diameter to those which involve an entire lobe They are often multiple and are always situated in the peripheral portion of the lung The commonest sites are in the regions of the junctions of the pleural surfaces one or more pleural surfaces always being involved The costophrenic sinuses the borders of the lobes and the mediastinal margins of the lung are the most frequent locations Hampton and Castleman in their classical study found that while infarcts may occur in any portion o



Fig 146 —Infarcts Bilateral

There is a large area of infarction in the peripheral portion of the left mid lung field. The infarct is triangular in shape with the base of the triangle directed toward the periphery of the lung field At the right base there are multiple smaller infarcts and patches of congestion The heart shadow shows marked enlargement to the left in the region of the ventricle

ing 74 per cent were located in the lower lobes the right side being much more requently affected than the left The shape of the infarct varies with the onfiguration of the portion of the pulmonary field in which the lesion occurs and he direction of its long axis In the sagittal roentgenogram there is apt to e a triangular area of diminished radiance although in many cases the shadow on



Fig 147 —Pulmonary Infarct

A The right diaphragm is markedly elevated flattened and hazy There is a band of density at the right base in the region above the diaphragm an infarct

B Two weeks later The infarct has undergone partial absorption and organization the density at the right base having decreased in size and being irregularly mottled in character The elevation of the diaphragm is less marked

The roentgen picture in pulmonary embolism without infarction is characteristic The ischemia of the affected segment of the lung results in an area increased radiance which is segmental in distribution and shows complete absence of the vascular pattern Centrally to the site of the lesion the bronchovascular markings are normal The involved area may show increased density with sharp demarcation of its outlines and the involved vessel These changes may affect a single segment a lobe or the entire lung As with other types of infarcts the shape of the lesion varies widely and is determined by the configuration of the involved segment The embolus may undergo organization recanalization or absorption In the latter instance the circulation is resumed the area



FIG 1 0—Multiple Small Infarcts Cardiac Decompensation with Congestion There is chronic rheumatic heart disease with congestion The congestion is manifest by enlargement of the hilum shadows and prominence of the bronchovascular markings about the roots of the lungs There is a massive infarct in the *lower third of the right lung* field The patient died two days after the roentgenogram was made Post mortem study revealed pulmonary congestion chronic rheumatic heart disease multiple infarcts at the right base and thickening of the pleura bilaterally

radiance disappears and the normal densities and markings of the lung are restored Rarely there is increasing or retrograde thrombosis with involvement of a larger area In differential diagnosis one must include chiefly obstructive emphysema associated with partial or incomplete bronchostenosis and localized *patches of non obstructive emphysema* *In obstructive* emphysema there is homolateral displacement of the heart and mediastinal contents during expiration depression of the diaphragm widening of the interspaces and preservation or accentuation of the lung markings

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PULMONARY CONGESTION

Active pulmonary congestion is characterized by an increase of the flow of ...od to an area of the lung which has suffered trauma or inflammation The ...aller vessels of the affected portion of the lung are enlarged and increased in ...sity The hilus shadows may or may not be enlarged Passive pulmonary

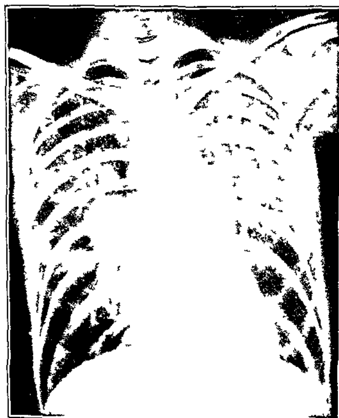


Fig 151 —Pulmonary Edema Associated ...th Mitral Heart D...e se

There i... irregular mottled den...ity about the roots of the lungs decr... sing toward the ...riph...ry ...n... the ba...al porti...ns of the lung fields The di...tr...bution about the h...la and in ...e mid lung is characteristic of c...ge...tion asso...iated with mitral heart disease Th...re is ...mpensatory emphysema at the bas...s ...nd the axill...ry p...rtions of the lungs There is evidence of flu...d at th...e ba...es Th...e he...rt sho...s the typic...l mitral configurat...on

congestion is due to damming back of blood in the pulmonary veins as a re... of increased pressure from the left auricle The lower portions of the lu... involved principally The roentgenogram characteristically has the appeara... of a poorly exposed or underdeveloped film because of the poor contrast in th... lung fields resulting from the fluid content of the lungs and the increased co... nective tissue in the interlobar septa (Figs 151 152)

The smaller branches of the pulmonary arteries are dilated resulting in gene... ized prominence of the bronchovascular markings The lung fields show a dif... haziness The hilus shadows are large and irregular and there are scatter... areas of patchy and linear density throughout the lung fields The change a... most marked about the hila and at the bases diminishing toward the apices a... the peripheral portions of the mid lung fields In rheumatic heart disease w...



FIG 152 —Congestive Changes

There is irregular mottled density throughout both middle and lower lung fields... the bases the density is uniform in character and obliterates the outlines of the diaphra... and the costophrenic angles The density at the left base rises higher in the axilla... in the mid portion of the lung field consistent with fluid The heart shadow is enlarged... the right and left There is compensatory emphysema of the apices and infraclavi... regions The findings are typical of congestive changes with fluid at the bases secondary... cardiac decompensation

congestive changes there may be a diffuse fine mottling throughout the l... fields which closely simulates the changes in miliary tuberculosis lympha... spread of metastatic carcinoma silicosis and fungus infections The enlarge... of the heart and prominence of the shadow of the auricles aid in the diag...

PULMONARY MANIFESTATIONS OF AZOTEMIA—UREMIC EDEMA OF THE LUNGS

Cases of pulmonary congestion associated with uremia produce a ty... roentgen picture (Figs 153 154 155) The distribution and type of the ch...

are characteristic There is increased density in both mid lung fields most marked about the hila and decreasing toward the periphery The apices and bases are not involved The density is usually symmetrical fine or coarse and occurs in the form of large lobulated areas Lateral projections demonstrate that the areas of density are centrally located The distribution is best described as butterfly like The roentgen picture is of transitory nature and tends to change rapidly or disappear completely within a short time The involved area may present a nodular appearance closely resembling neoplastic or pneumonic disease *The picture may also closely simulate cardiac decompensation because of the*



Fig 153 — Uremic Congestion

There is diffusely diminished radiance arranged in a butterfly pattern throughout the iddle and lower lung fields characteristic of uremic congestion The apices and extreme ises are uninvolved The hilus shadows are not enlarged The heart shadow is normal in e contour and position

neralized hypervascularity which sometimes occurs However in congestive eart disease the accentuated markings extend to the extreme peripheral and asal portions of the lung fields and the enlargement of the hilar and mediastinal adows is less marked than in uremic edema The densities in the lungs may ssume a mottled appearance which closely simulates metastatic carcinoma or rcoidosis

The patients may present no symptoms other than a slight cough and the entgen findings may be the first intimation of the condition There is a correla on between the degree of edema and the elevation of the blood urea nitrogen

and creatinine content the lung densities increasing as the blood nitrogen rises With return of the blood findings to normal the pulmonary shadows disappear completely often within a few days Infection is not a factor Rarely the involvement is unilateral in which instance only one side is affected The basis of the changes is an intra alveolar edema dilatation of the pulmonary vessels and interstitial congestion with transudation and exudation into the interstices and alveolar spaces of the lungs throughout the involved areas There is no element of infection There is often associated renal disease Pulmonary manifestation are



Fig 154 —Pulmonary Congestion Uremic

There is a butterfly distribution of increased density and mottling in the middle and lower lung fields the change being most marked in the regions adjacent to the heart The margin of the area are lobulated The density is coarse and granular The apices bases and peripheral portion of the lung fields are not involved The changes cleared rapidly and re examination few days later showed both lung fields of normal radiance The blood urea nitrogen which had been markedly elevated had returned to normal when re examination showed disappearance of the densities in the lungs

considered a poor prognostic sign and if recovery is to occur a rapid clearing of the lung densities and a fall in the blood area nitrogen should take place promptly Hypertensive heart failure may also be present and is an important consideration in prognosis Similar changes may occur in chronic nephritis post operative heart failure diabetic coma and after intracranial operations

BLAST INJURIES OF THE LUNG (PULMONARY CONCUSSION)

Persons in close proximity to the detonation of high explosives suffer a diffuse capillary hemorrhage of the lungs. This type of injury is rare in civil life but occurs frequently in military bombings, particularly in persons bombed in closed spaces. The condition is characterized chiefly by bleeding from the alveolar capillaries. In very severe cases there is massive hemorrhage and rupture of the goblet cells with the liberation of large amounts of mucus. The changes are usually bilateral. The severity of the manifestations depends upon the force of the explosion, the distance from the blast, the surroundings, and the condition of the patient. Many cases are characterized by instantaneous death with no external signs of injury. In most instances, however, the changes are less severe



Fig 155 —Uremic Edema of the Lungs

There are symmetrically distributed areas of increased density in both mid lung fields. The butterfly pattern is well illustrated. The heart shadow is normal in size and contour, indicating that the changes are not due to cardiac decompensation.

and the patients recover. Clinically there is marked prostration, dyspnea, tachycardia, and a sense *of oppression or severe pain in the chest.* Subsequently *there* is cough and fever. The clinical manifestations may be those of congestion, consolidation or atelectasis. There may be bulging of the chest. The onset of the symptoms may be delayed for many hours after the trauma.

Roentgen Manifestations. There is diminished radiance over the lung fields with multiple scattered areas of mottled density. The findings closely simulate those in congestion or atelectasis. The changes are usually bilateral and are most *marked about the* hila and at the bases. *Pulmonary edema of varying* degrees may occur. Pneumonia may develop as a sequel.

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POST IRRADIATION FIBROSIS OF THE LUNG

Roentgen therapy to the chest is widely used in the treatment of malignant lymphoma carcinoma of the lung metastatic neoplasms and tumors of the breast Numerous cases of extensive injury to the lung after roentgen irradiation have been reported The damage appears under the portion of the chest that has received the heaviest dosage and if crossfire techniques have been utilized it occurs at the point of convergence of the beams Massive doses repeated at short intervals are particularly apt to produce injury even though the total dosage is not high Irradiation limited to the peripheral portions of the lung is less likely to cause deleterious effects than exposures over the mediastinum The use of large fields is conducive to the production of pulmonary changes

The lesions which may ensue from excessive exposure comprise progressive fibrosis of the lung thickening of the pleura marked elevation and fixation of the diaphragm narrowing of the intercostal spaces and retraction of the mediastinal structures to the affected side A less commonly under tood sequel of irradiation is increased vascularity of the bronchial linings which leads to hemoptysis often of severe proportions Further irradiation may stop the hemorrhage However a vicious cycle may thus be established There is hemorrhage deep roentgen irradiation to relieve the hemorrhage which results in more scar tissue with increased bronchial vascularity requiring more deep roentgen therapy and hemorrhage again The changes in the affected lung may produce compensatory emphysema on the opposite side There is increased susceptibility to infection It must be borne in mind that in the treatment of neoplasm the therapy which is successful in killing the tumor may produce a series of changes which are very crippling or predispose to infection and other sequelæ Bone changes may occur in the areas under treatment and are in the nature of a rarefying osteitis The ribs show narrowing irregularity of outline osteoporosis and sharply outlined areas of rarefaction Pathologic fracture without trauma occurs in the rib or clavicle and non union is the rule

The cellular structure of the lung is such that it is one of the less radio-sensitive organs It is a spongy cavernous tissue with epithelial and vascular surfaces separated by chambers filled with air the alveoli The bronchial epithelium, the cartilage and smooth muscle are more radio-resistant than the specialized cells in the parenchymatous organs However with high voltage therapy there is a high incidence of changes in the non tumor containing portion of the irradiated lung These may be only of minor clinical significance although prolonged a

widespread exposure may produce serious consequences After intensive treatment for carcinoma of the breast there may be a diffuse haziness in the region of the hilum which spreads as an irregular area of increased density outward into the lung and reaches its maximum in 3 to 4 weeks Some cases regress and leave only an appearance of slight fibrosis with multiple linear interlacing shadows In other instances there is thickening of the pleura consolidation and pulmonary fibrosis which does not clear up There are two types of irradiation pneumonitis 1) a segmental or localized patch of diffuse mottling radiating from the mediastinum to the periphery (Fig 170) and 2) extensive areas of density which involve practically the entire lung with retraction of the heart and trachea to the affected

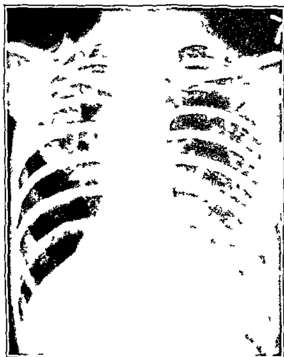


FIG 170 —Post Irradiation Fibrosis of the Lung

There is an area of increased density in the upper third of the right lung field The right diaphragm is markedly elevated and flattened There is a triangular area of density in the paracardiac portion of the right lower lung field The heart and mediastinal contents are deviated markedly to the right There is marked narrowing of the interspaces on the right the right lung field being smaller than the left On roentgenoscopy the right diaphragm is markedly limited The patient had received deep x ray therapy subsequent to resection of the breast for carcinoma The changes closely simulate tuberculosis

side general fibrosis elevation of the diaphragm and narrowing of the rib spaces Pleuropericardial adhesions and pleural pericardial or interlobar effusions may develop Atelectasis is common with bronchitis and bronchiectasis supervening Severe fibrosis develops after an interval of years and plaques of calcification form in the lung parenchyma and the pleura Enlargement of the

ARTERIOVENOUS ANEURYSMS OF THE LUNG

In the past the diagnosis of arteriovenous aneurysm has been made only at operation However the condition can frequently be diagnosed pre operatively on the basis of the clinical and roentgen manifestations If adequate therapy is not instituted death usually results from massive hemoptysis The condition is amenable to surgical treatment and accurate early diagnosis may be a life saving procedure The symptomatology consists of polycythemia cyanosis clubbing of the fingers and toes repeated hemoptyses shortness of breath and weakness A bruit or hum may be heard over the lungs on auscultation There is a marked increase in the circulating blood volume This is probably due to cyanosis produced by the shunt of the venous blood from the pulmonary arteries directly into the pulmonary vein and thence into the peripheral arterial system without oxygenation of the shunted blood The increased total volume of the circulating blood is due to increase in the red blood cells but not of the plasma After operation the red blood cell volume decreases Clubbing of the fingers and toes is associated with the impaired oxygen content of the peripheral arterial blood There is marked reduction in the oxygen saturation of the arterial blood This is explained by the veno arterial shunt in the pulmonary aneurysm A lobulated or rounded mass in the lung field connected with the hilus by a band like vascular shadow comprises the significant roentgen finding in arteriovenous aneurysm (Fig 179) Pulsations occur in the presence of large vessels leading to the lesion and may be noted during roentgenoscopy or on kymographic study Laminography is of value to demonstrate the connection of the tumor like shadow with the hilum Angiography is of aid in diagnosis but a case has been reported in which death resulted from this procedure The Valsalva test is important in determining the vascular nature of the lesion there being a marked decrease in the size of the mass the lobulations becoming more distinct and the band like communications with the hilum of the lung becoming more clearly demonstrable when the patient strains or attempts to exhale against the closed glottis at the end of a full inspiration Hemorrhage in and about the lesion may obscure the roentgen changes Small rounded areas of increased density are not infrequently present in other portions of the lung due to additional hemangiomatous malformations

Tumor of the lung is usually confused with the arteriovenous aneurysm and is the chief difficulty in differential diagnosis However the clinical manifestations of carcinoma of the lung are at variance with those associated with arteriovenous aneurysm In polycythemia vera there may be scattered rounded areas of density in the pulmonic field These are not vascular in character and do not change in size on the Valsalva test An arteriovenous aneurysm in the peripheral circulation causes cardiac dilatation and signs of congestive failure the larger the shunt and the closer to the heart the more marked the change Arteriovenous aneurysm of the lung does not cause cardiac enlargement Bronchiectasis must be considered due to the hemoptysis and the clubbing of the fingers

There is no cyanosis or increased red cell count and volume in bronchiectasis Mitral stenosis may cause hemoptysis and cyanosis There are typical changes in the heart and a characteristic murmur in mitral disease Congenital heart lesions with cyanosis including pulmonary stenosis the tetralogy of Fallot and Eisenmenger's complex with an overriding aorta are frequently associated with cyanosis dyspnea clubbing and dizziness There is no hemoptysis and the roentgen and electrocardiographic signs in these conditions are usually characteristic



Fig 179 —Arteriovenous Aneurysm of the Lung Angiography

The arteriovenous aneurysm is visualized as a rounded sharply defined mass in the paracardiac portion of the right lower lung field The vascular communication between the aneurysm and the root of the lung is clearly delineated

A Sagittal Roentgenogram There is a rounded sharply defined area of density in the paracardiac portion of the right lower lung field There are two vascular shadows which show visible pulsations extending from the mass to the right hilum (black arrow) The right hilum is low

B Lateral Projection The soft tissue mass lies in the region of the right middle lobe (black arrow)

C Two Seconds after Intravenous Injection of Diodrast The artery leading to the tumor mass and the mass are opacified The vein is visualized as a less dense shadow adjacent to the artery

D Two Seconds Later The mass is more clearly visualized (black arrow) The vein and artery are opacified There is extensive filling of the pulmonary vascular tree



Fig 191 —Hodgkin's Disease

A No 14 19 An irregular sharply defined area of density extends *into the r h*
mid lung field

B April 2 1937 The *mass in the right lung field* is larger and the *supracardiac* area is markedly widened bilaterally due to involvement of the mediastinal glands

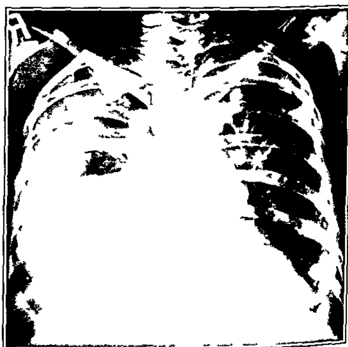


Fig 192 —Malignant Lymphoma with Mediastinal Involvement and Fluid in the Right Chest

There are masses of glands in th mediastinum and about th hila more on the r h
Th re i uniform density in the axillary and inferior portions of the ri ht lung field
displacement of the heart and tra hea to the left fluid in the right chest cavity

these changes may be of great aid in arriving at a diagnosis Injection of diodrast into the veins of the arm may show obstructions in the venous circulation and is of diagnostic value in certain instances of neoplasm and other lesions in the mediastinum The heart great vessels and esophagus are considered in detail separately and will not be discussed in this section

MEDIASTINAL TUMORS

The Hodgkin's group of lymphomas and lymphosarcomas comprise the commonest neoplastic diseases of the mediastinum and usually manifest themselves by varying degrees of enlargement of the mediastinal glands (Figs 190–195) The right paratracheal lymph nodes are the most frequently involved In some instances the condition remains confined to a single node or group of glands for long periods As the process advances there usually develop bilateral enlargements of the glands with increase in the width and density of the supracardiac and hilar shadows The margins of these shadows are discrete and sharply defined being either lobulated or straight The involvement may be much more extensive on one



Fig 193 — Hodgkin's Disease of the Mediastinum with Narrowing and Displacement of the Esophagus

Bucky roentgenogram The esophagus is narrowed and displaced (white arrow) due to pressure from the large mediastinal mass The trachea is compressed and deviated to the left

side than on the other Enlarged glands may also develop in the supraclavicular regions axillas and other portions of the body In doubtful cases a therapeutic test consisting of the administration of a small or moderate dose of x radiation may be helpful in diagnosis the lymphomas and lymphosarcomas showing a marked reduction in size after therapy In leucemia there may also occur enlargement of the glands about the roots of the lungs although this is less common Tuberculosis may cause marked increase in the size of the mediastinal glands (Figs 196 197 198) In carcinoma of the lung of the infiltrating type, hypertrophy of the mediastinal glands is common and may result in masses of very large size Other lesions which may manifest their presence by enlarged mediastinal glands are sarcoid

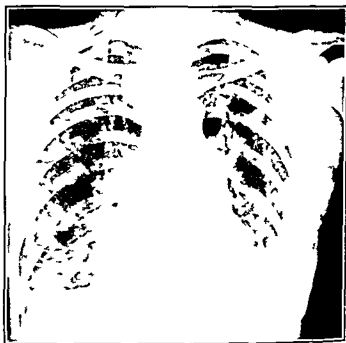


Fig 196 —Enlarged Mediastinal Glands Healed Pulmonary Tuberculosis Calcified Glands at the Hila and in the Axilla

The mediastinal glands are enlarged and there are multiple calcific nodes about the hila and in the left axilla There is bilateral healed tuberculosis with irregular calcification in the left infraclavicular region The left diaphragm and costophrenic angle are obliterated due to pleuritis and pleural thickening at the left base

erythema nodosum infectious mononucleosis (*see* Fig 199 p 294) fungus diseases silicosis and metastases from carcinoma of the lung stomach kidney and pancreas Calcific nodes in the mediastinal glands are usually residuals from healed tuberculosis In general large masses of glands in the mediastinum during infancy and childhood are due to tuberculosis while in later life the lymphomas malignancy or other diseases mentioned above are the more probable cause

Substernal thyroid produces a rounded or pyramidal mass with displacement and narrowing of the trachea the density often extending into the upper or middle third of the chest (Figs 200 202) In rare cases a substernal thyroid may lie posteriorly to the trachea (Fig 201) The neurofibromas are usually single sharply cı

cumscribed unilateral lie well posteriorly and tend to erode the ribs vertebræ or vertebral pedicles (Figs 204 205) Aneurysm of the aorta and innominate artery may be of any size and shape and lie anywhere in the chest and while usually described as pulsatile many show no pulsations Aneurysm of the innominate artery usually elevates the aortic arch while substernal thyroid may cause a depression of the arch of the aorta Lipoma of the mediastinum produces a radiant lobulated shadow Paravertebral abscess may be visualized as a fusiform density extending longitudinally along either side of the spine and in cases of long standing irregular or linear calcification may be present Destructive



Fig 197 —Enlarged Hilum Gland Due to Tuberculosis

There is a rounded lobulated area of increased density at the left hilum a mass of enlarged gland The enlargement of the glands was due to hilum tuberculosis

changes in the vertebræ and intervertebral spaces are often present in tuberculosis of the spine and make the diagnosis clear Tumors of the parathyroid gland are usually small and produce no roentgen manifestations of their presence They may rarely result in the formation of large masses in the mediastinum with compression and deviation of the trachea and less frequently the esophagus also (Fig 203) A meningocele may project anteriorly and be visualized as a rounded or ovoid area of increased density in the posterior mediastinal region

Important additional data as to the nature size and location of mediastinal tumors may be obtained by angiocardiocardiography and venography The former procedure is of particular value in the differentiation of an aneurysm of the

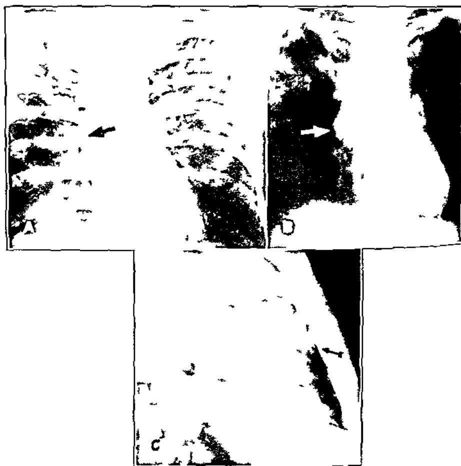


Fig. 706—Endothelioma of the Anterior Mediastinum

A Sagittal roentgenogram of the chest There is a rounded area of increased density in the region of the right hilum (black arrow) The margins of the area of density are sharply defined and slightly lobulated

B Laminogram The mass at the right hilum is clearly outlined and the lobulation of the periphery of the mass is well demonstrated (white arrow)

C Lateral roentgenogram of the chest The area of density lies in the anterior mediastinum adjacent to the body of the sternum (black arrow) At operation the tumor proved to be an endothelioma

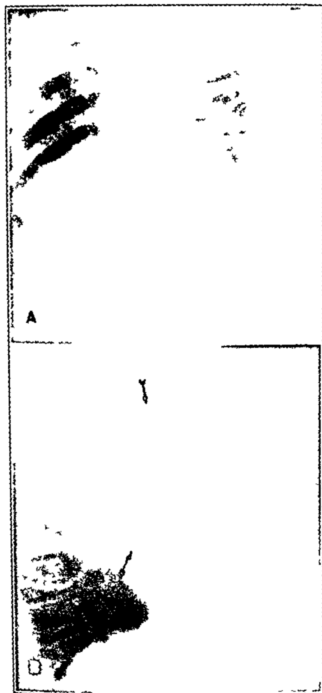


Fig 207 — Teratoma of the Mediastinum

A Anteroposterior projection There is a rounded soft tissue mass in the right paravertebral region The outer margins of the mass are smooth and sharply defined Roentgenoscopic observations revealed no evidence of pulsations in the mass

B Lateral projection The area of soft tissue density lies in the anterior and mid portions of the chest and overlies the shadow of the heart and great vessels (black arrows)

Operation revealed a teratoma of the mediastinum



Fig 210 — Mediastinal Tumor Venogram

On th left side the venous structures are sl htly dilated On the ri ht there is mark dilatati n and tortuo ity of the veins due to obstruction (arrow) The ext nt and site the h n es are imp rtant aids in the localization and diagnosis of mediastinal tumors

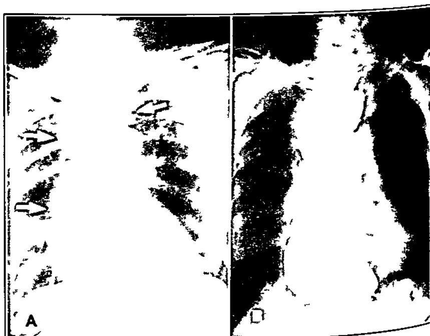


Fig 211 — Cardiospasm Demonstrated on Roentgenogram of the Chest

A Sagittal projection The supracardiac area is widened to the right and there is a sharp defined lobulated density in the right paravertebral and paracardiac re ions su est the presence of a large mediastinal mass (white arrows) However the ext nt of the cha from the level of the clavi le to the extreme base is not typical

B After the administration of an opaque meal The markedly dilated esophagus is cl outlined Comparison with A it will be seen that the densities orrespond almost e a



Fig 212 — Cardiospasm Demonstrable on Roentogram of the Chest

There is a sharply defined linear density adjacent to the shadow of the spine in the right upper and mid lung fields (white arrow) There is a band of increased radiance in the right and left paravertebral regions (black arrows) which suggest the presence of mediastinal emphysema The radiant shadows extend to the level of the clavicle and the possibility of cardiospasm with air and fluid in a markedly dilated esophagus should come to the observer's mind The administration of an opaque meal demonstrated marked dilatation of the esophagus due to cardiospasm

In general symptoms fall into groups suggesting peptic ulcer gastrointestinal malignancy gallbladder disease or heart disease Realizing that an absolute differentiation cannot be made the best we can do is to group the material according to predominant symptoms (Table 5)

Of the 9 patients without symptoms 4 had small hernias and 5 had large hernias with eventration of at least two thirds of the stomach



FIG 237 — Esophageal Hiatus Hernia in a Child Three Weeks of Age
There is protrusion of a portion of the cardia of the stomach through the esophageal orifice of the diaphragm into the thorax (black arrow) a congenital hiatus hernia

Among the 13 cases with symptoms suggesting coronary disease one or more of the observers who saw these patients was of the opinion that 6 of the patients had definite coronary artery disease in addition to a hiatus hernia and in one case this opinion was supported by suggestive electrocardiographic changes Finally it should be mentioned that in the 82 cases with symptoms suggesting either gallbladder or gastrointestinal disease careful x ray studies revealed no disease other than a hiatus hernia Despite this fact several patients in this group were unnecessarily submitted to surgery

Table 6 lists the symptoms in 95 cases regardless of the size of the hernia An attempt was made to classify the symptoms according to the size of the lesion but without clear cut differential data It is to be remembered that hernial size may change from time to time and that a single observation by x ray is not necessarily an accurate basis for a definite classification At any rate in the 13 cases with symptoms suggesting coronary disease 5 patients had large, 2 moderately large and 6 small hernias



Fig 239 — Hiatus Hernia

Practically the entire stomach is above the level of the diaphragm only a small portion of the prepyloric area and the pylorus lying in the abdomen The duodenum is displaced markedly upward The duodenal loop is uncoiled and abnormal in position There is marked rotation of the stomach and the esophagus appears to enter the stomach posteriorly



Fig 240 — Large Hiatus Hernia Intrathoracic Stomach

Practically the entire stomach lies in the thorax The stomach is inverted the so-called upside down stomach The cardia lies at a lower level than the media The cardio-esophageal junction is in normal position (white arrow) The cardia is inverted and the media and antrum extend upward The pylorus and duodenum are directed downward The second portion of the duodenum is markedly elongated and the duodenal loop is only partially formed



FIG [illegible] —Localized Pneumothorax Involving the Right Apex and Upper Lung Field

A Conventional roentgenogram There is increased radiance with absence of lung structure at the right apex and in the upper third of the right lung field There are linear strand like areas of increased density at the level of the second right interspace anteriorly due to compression at [illegible] of the collapsed portion of the lung

B Laminogram The absence of lung structure in the region of the right upper lung field is clearly demonstrated The compression atelectasis of the upper portion of the right lung is well shown [illegible]

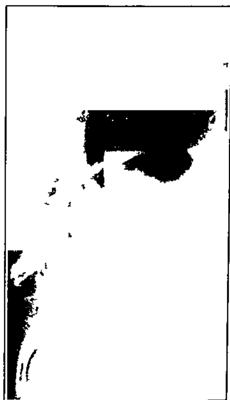


Fig 70 — Empyema Cavity Outlined by Iodized Oil

The pati nt had a chr mic empyema which drained intermittently during a period of many months Inj cti n of iodized oil outlines the sinus tract and shows the extent of the cavity There is increased density in the lower lung field due to thickening of the pleura There is a localized pneumothorax and operative defects in the lower ribs

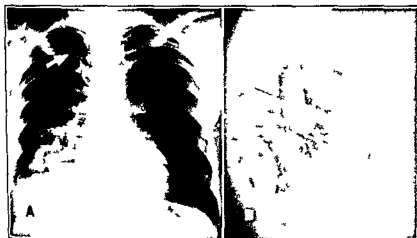


Fig 271 – Empyema Bronchopleural Fistula Azygos Lobe

A Sagittal view An empyema had been present for two months In order to determine the approximate size and location of the affected area iodized oil was injected into the sinus The opaque material demonstrates the extent of the lesion The right diaphragm is elevated and flattened and the right costophrenic angle is obscured These observations are important in planning surgical therapy as tapping the chest at too low a level may result in penetration of the diaphragm with resultant subphrenic abscess There is a linear sharply defined area of increased density in the paravertebral portion of the right apex and upper lung field This density has the shape of an inverted comma and represents an azygos lobe (white arrow)

B Lateral projection The opaque material accumulates in the posterior aspect of the right lower lung field The margins of the empyema cavity are well outlined by the opaque medium and show the extent and localization of the process Iodized oil is present in the trachea and bronchial tree indicating the existence of a bronchopleural fistula

thorax subsequent to thoracentesis and tracheotomy, and in operations on the neck and chest In some instances it develops spontaneously in the absence of *previous trauma and without underlying disease of the respiratory tract*

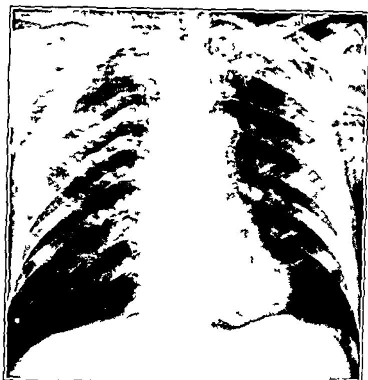


FIG 291 —Subcutaneous Emphysema

The patient suffered a crushing injury of the chest and had multiple fractures of the ribs There is marked subcutaneous emphysema with air in the soft tissues of the chest the supraclavicular region the axillæ and the neck The air is distributed along the fascial and muscle plane There is no evidence of collapse of the lungs or of fluid in the pleural space

Funnel Chest Deformity —The anomaly known as *funnel chest is readily* demonstrable on clinical examination and in lateral roentgenograms of the thorax In the *sagittal roentgenogram the changes may easily be overlooked* The *condition is developmental and may be hereditary* The deformity consists of an oval or funnel shaped depression of the body of the sternum and the adjacent costal cartilages The body of the sternum is usually involved below the manubrium There is increased angulation between the costal cartilages and the rib The sternum usually rotates on its long axis so *that the anterior surface* faces obliquely most often toward the right side The depth of the depression varies with a corresponding variation in the vertebral sternal diameter which may be narrowed to a very few centimeters There is distortion and *deviation of* the mediastinum and its structures The heart is displaced to the left and rotated on its longitudinal axis The mediastinal pleural space is *increased in width* and *there may be transverse compression of* the lungs bilaterally The diaphragm is more caudal in position than normally and the vertical diameter of the lungs is increased The esophagus may be tortuous or compressed

The roentgen manifestations which may be demonstrable in the anteroposterior roentgenograms are as follows 1) Sharp downward slanting and straightening of the anterior aspects of the ribs 2) The heart shadow is displaced and its left margin appears straight or slightly prominent 3) The heart border on the right becomes indistinct being obscured by the spine 4) The cardiac shadow shows diminished density and the spine is more clearly outlined than

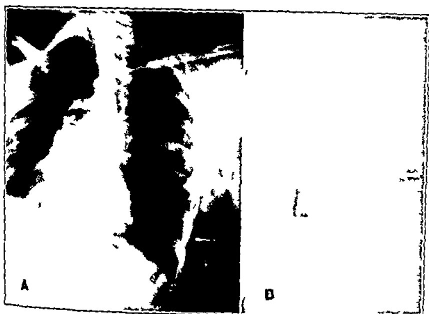


Fig 292 —Funnel Chest Deformity

A Sagittal projection There is marked scoliosis to the left in the [illegible] deformity of the chest The heart and trachea are deviated to the right [illegible] phragm is markedly elevated The appearance is that of a s[illegible]n later[illegible] the chest

B Lateral projection The lower portion of the body of the sternum [illegible] and sharply angulated There is complete obliteration of the area [illegible] is [illegible] between the middle segment of the sternum and the [illegible]

[illegible] The medial aspect of the right lung field is hazy due to the depression of the sternum and compression of the lung These changes may suggest atelectasis pleural thickening or inflammatory consolidation In the lateral projection the depression of the body of the sternum and the markedly decreased distance between the sternum and the spine are clearly demonstrable (Fig 292)

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ROENTGEN DIAGNOSIS OF DISEASES OF THE BREAST

Introduction —On the routine roentgenogram of the chest the female breasts are usually visualized as faintly outlined areas of increased density in the inferolateral aspects of the thorax at about the level of the diaphragm Small underdeveloped or atrophic breasts may cast practically no shadow Large pendulous breasts may on the other hand produce markedly diminished radiance and haziness over the lower lung fields and interfere with accurate study of the basal portions of the lung fields the cardiac borders the outlines of the diaphragm and the costophrenic angles This difficulty can usually be overcome by making the roentgenogram in the anteroposterior projection rather than the more commonly used posteroanterior view or by using the Bucky diaphragm with a higher kilovoltage resulting in greater penetration of the x ray



Fig 293 – Absence of the Left Breast

The right mammary shadow is clearly outlined (white arrow) The left breast was removed because of carcinomatous involvement The increased radiance at the left base is due to the absence of the shadow of the left breast Failure to observe the fact that the left breast is not present may result in a diagnosis of emphysema at the left base or of prominence of the markings and diminished radiance at the right base

Asymmetry of the breasts may result in changes in the roentgen densities at the bases of the lung Subsequent to mastectomy the remaining breast produces an area of increased density over the inferior aspect of the thorax and a marked difference in the radiability of the lower lung fields on the two sides may easily be misinterpreted as being due to a pathologic process In patients with marked variation in the size of the breasts and those who have had operative

removal of one breast the use of the anteroposterior projection will [illegible] lessen or eliminate the difference in radiability of the two sides of the [illegible] The radiologist must train himself to consciously observe the mammary [illegible] in all patients Absence of the outline of one breast may supply the [illegible] clue in a doubtful case and establish the diagnosis of metastatic carcinoma [illegible] without this important data a definite differential diagnosis might [illegible] The nipple particularly when pigmented can produce a round [illegible] creased density which may easily be confused with neoplastic formation [illegible] serious pulmonary disease



Fig 294 —Asymmetry of the Breasts

The right breast shadow is large (white arrow) The left br[illegible] being faintly indicated at the black arrow The increased density [illegible] base are due to the shadow of the right breast and may easily be misinterpreted [illegible] to a pathologic process in this region The shadows of the breasts must b[illegible] in all roentgenograms of the chest Re examination with the patient in th[illegible] position rather than in the more commonly used posteroanterior [illegible] radiance at both bases

The female breast particularly if large and pendulous lends itself particularly well to roentgen examination By the use of special technique complete and detailed visualization of the breast is possible Very low kilovoltage exposures are utilized in order to outline the details of the structure of the mammary organ No special preparation of the patient is required and the examination can be carried out with the equipment available in every roentgen laboratory The roentgenograms may be made with the patient erect or recumbent The clarity with which the breast structures can be visualized is surprising and the techniques can be easily acquired

Roentgen examination affords a reliable and comparatively easy method studying the structure physiology and pathology of the female breast Ne plasms and other pathologic processes may be diagnosed roentgenographica and the changes associated with menstruation pregnancy and the menopau may be demonstrated On clinical examination, it is often impossible to dete mine whether or not a mass is present in the breast Transillumination h proven undependable as a method of diagnosis The necessity for repeated palp tion and diagnostic operation may be greatly lessened by roentgen study

Anatomy The adult female breast is composed of a number of lobes whi are subdivided into lobules and separated from one another by connective ti su and elastic septums Histologically the breast is made up of three prime element 1) Glandular structures 2) Fibrous tissue and 3) Fat The lactiferous duc number from 15 to 20 and converge centrally toward the alveoli and unite to for the canals that conduct the milk to the nipple During pregnancy the glan tissue undergoes hyperplasia and the ducts elongate At the same time th connective tissue diminishes so that the lactating breast is made up principally o ducts acini and blood vessels with little or no fibrous elements After th cessation of lactation the acini atrophy but the ducts do not and as the breas shrinks there is marked convolution and apparent increase in the number o ducts During each menstrual period similar but much less marked change occur The fibrous tissue forms septums between the lobes and is outside th smooth muscle on which the glandular epithelium rests The fat lies in the lob in a loosely constructed fibrous tissue the amount of fat varying widely wit the size and conformation of the breast

Technique — The roentgen studies require no previous preparation of th patient and cause no pain or discomfort No special apparatus is required The Bucky diaphragm is used with a fine focus tube and intensifying screens A soft tissue technique is utilized and the patient must remain entirely immobile durin the examination It has not been necessary to use injections of opaque materials gas or air into the ducts or tubules of the breast and most observers do not feel that these measures are necessary as the plain roentgenograms of the breast supply all necessary data Pathologic processes are visualized in the breast be cause they cause distortions of the structures or are more or less dense than the normal tissues of the mammary gland

The Normal Breast (Fig 296) — Normally the ducts are seen as multiple sharply defined irregular linear striations varying in width from one to several millimeters These striae are somewhat feathery and traverse the breast shadow obliquely to converge toward the surface in the region of the nipple The acini consist of numerous fine mottled areas of density continuous with the shadows of the ducts The acini and ducts are usually arranged in a roughly triangular form with the base of the triangle adjacent to the chest wall and the apex directed toward the anterior and interior portion of the mammary gland in the region of the nipple The main mass of the breast appears as a homogeneous or slightly mottled area of density Mammary glands with large amounts of fat are par ticularly difficult to examine clinically but lend themselves readily to roentgen study and produce sharp roentgenograms with good contrast and detail The skin and subcutaneous fat layer are shown in profile along the outer edge of the breast and are less dense than the main mass of the mammary gland The nipple is visualized as a rounded or oval area of density particularly if pigmented Extend



Fig 795 —Haziness at the Bases of the Lung Fields Produced by Enlarged Breast Shadows

The patient is one week post partum The breasts are markedly enlarged The haziness and diffuse linear densities at the bases are due to the overlying breast shadows and should not be misinterpreted as being due to pulmonary pathology

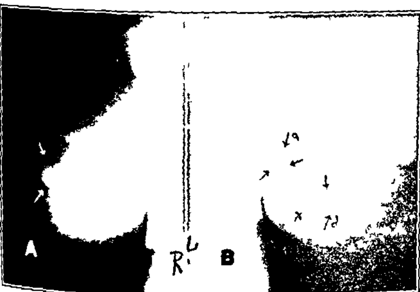


Fig 796 —Normal Breast

Soft tissue studies of the breast are valuable to show the structure of the breast The nipple in the multiparous patient is visualized as a rounded area of increased density (n)

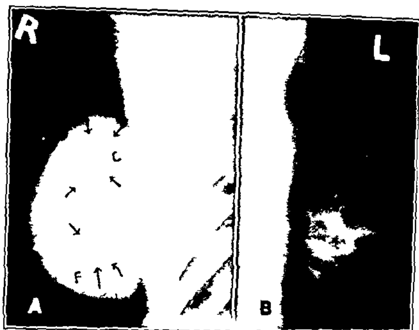


Fig 299 Cystic Mastitis Cystoplasia Cyst in the Right breast

There is a large rounded area of density occupying the lower and mid portions of the right breast In the *upper pole of the right breast there is* an ovoid area of increased radiance outlined by the arrows which *represents a* cyst formation The left breast presents numerous coarse striation *with a* irregular pattern consistent with chronic cystic mastitis cystoplasia

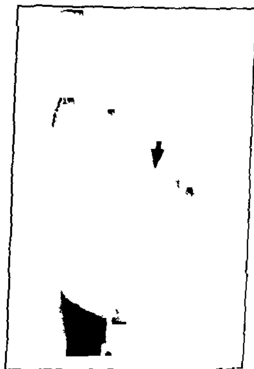


Fig 300 Cystic Mastitis with Cysts

There is a large rounded area of increased density in the anterior third of the breast (white arrow) a large cyst A small cyst is present in the upper portion of the breast (black arrow)

100)

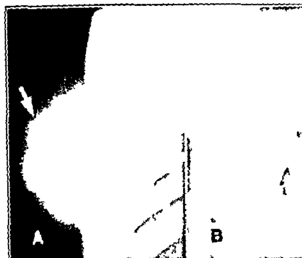


Fig. 301 [illegible]

There is a small area [illegible] arrows) The striæ are preserved [illegible] seen at the white arrows

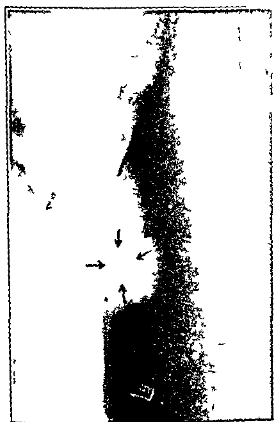


Fig. [illegible] B

There is an [illegible]



Fi 06 — Advanced Carcinoma of the Left Breast

Th left brea t i shrunken and within it there is a large irregular area of increased density characteri tic of d an ed ar in ma f the breast



Fi 07 — Marked Enlargement of the Right Breast in Hodgkin s Di ease

There i a lar e r unded soft ti sue density hich repre ents a markedly enlar ed ri ht brea t i hit rr) The supracardiac area is idened to the right The soft tissues of the neck and upra la i ular region are increased in density and thickness The patient had ad an ed Hodgkin disea e with invol ement of the glands of the right side of the neck supracla icular regi n mediastinum and axilla The right breast was tremendou ly enlarged and obs ur d the utl ne of the right lung the right diaphragm and the right costophrenic angle

early stages of malignancy and malignant degeneration in a formerly benign tumor are not demonstrable by roentgen methods The method is useful to demonstrate the presence of a neoplasm and to show its location and approximate size The malignant growth is visualized as a dense sharply defined mass (Figs 305 306) The margins of the mass are usually irregular and infiltrating but may be smooth When small the tumor causes little if any distortion of the breast structures As the tumor enlarges the structures are invaded or compressed The neoplasm may be multiple with two or more densities in the breast Inversion of the nipple and dimpling of the surface of the breast may be demonstrable and are important in diagnosis Irregular feathery extensions into the surrounding breast tissue from the main mass of the tumor are characteristic of carcinoma Lesions near the nipple often show a dense band extending from the neoplasm toward the nipple the so called bridge of tumor tissue The growth may extend posteriorly and invade the clear radiant area normally present between the breast and the chest wall Extensions to the ribs or metastases to the [illegible] are demonstrable roentgenographically and are of great importance in diagnosis and prognosis The study of the remaining breast in patients who have had a breast removed for carcinoma is important Serial roentgenograms of neoplasms of the breast are of great value in determining the rate of growth and observing the effect of therapy Glands in the axilla are frequently demonstrable as smooth sharply defined dense masses Inflammatory glands are usually denser and more sharply circumscribed than malignant glands

Section VI

THE SOFT TISSUES OF THE NECK

INTRODUCTION

THE study of the thorax should in every instance include careful observation of the neck. Among the conditions in this region which are of particular interest to the internist are cervical ribs, soft tissue tumors, foreign bodies, abscesses, tumors of the upper air passages, diseases of the cervical spine, and emphysema.

TUMORS OF THE SOFT TISSUES

The study of the soft tissues has been largely neglected by the majority of radiologists. Careful observation of these structures is very important and is of inestimable value in the diagnosis of many conditions which otherwise might not be demonstrable. By the use of proper techniques the normal details and many pathologic conditions of the fleshy structures can be visualized with a sufficient degree of clarity to permit of accurate study. The various components of the body have different degrees of density and therefore absorb x radiation to varying degrees so that it is possible to differentiate them by roentgen methods. In the field of diagnostic roentgenology there are 5 principal densities: 1) Gas. Gas and air offer very slight resistance to the passage of the x rays as the density of these substances is so low that the radiation passing through them is absorbed to only a very slight extent. Hence the roentgenogram in the region occupied by gas or air shows a very marked blackening. 2) Fatty or adipose tissue. Fat also absorbs only very small amounts of *x* radiation and casts a dark shadow on the roentgenogram, the degree of darkening being slightly less than is the case with gas. 3) Soft tissue structures. Soft tissue structures such as the muscles, nerves, parenchymatous organs and viscera as well as water and the body fluids produce approximately the same degree of change on the roentgenogram. These substances are definitely more dense than adipose tissues. 4) Bone and calcific formations within the body absorb much more radiation than the three groups described previously and in consequence cast a more dense shadow on the roentgenogram with less blackening of the film in the region occupied by these structures. 5) Metallic substances. Metallic substances may be introduced into the body by design for purposes of opacification or accidentally, as for example needle fragments, bullets or shrapnel. The iodine compounds are widely used in the study of the urinary tract, bronchial tree and uterus and barium salts are utilized for the examination of the gastrointestinal tract as these substances offer marked resistance to the passage of the *x* rays and are more dense than the structures in the previous groups. The greater the thickness of the tissue the more radiation it absorbs and the less black it appears on the roentgenogram so that variations in thickness may be as important as differences in density. Another important factor is the degree of density of the substances or organs adjacent to the region under observation. The air filled lungs are much more radiant than the heart

on various types of roentgenograms is essential if early or slight changes are to be detected The observer must also understand the location and type of calcific deposits which normally occur within the soft tissues Thus calcification of the costochondral regions or the cartilages of the larynx is not of pathologic significance However the demonstration of phleboliths in regions of the body where this calcification normally does not occur permits of a diagnosis of angioma

Most tumors of the soft tissues are so similar in density to the tissues within which they lie that accurate differentiation is impossible However differences in density may be demonstrable and in many instances a diagnosis of tumor may be established Roentgen study may make it possible to outline the size shape and point of origin of the neoplasm and to determine whether it is encapsulated



FIG 309 —Calcified Glands in the Soft Tissues of the Neck and Supraclavicular Regions

There are multiple small irregular areas of calcific density in the soft tissues of the neck and the supraclavicular regions bilaterally There are also numerous calcified glands in the region of the left hilum

or infiltrating Erosions or invasions of bone and other nearby structures are frequently demonstrable If the soft tissue mass projects from the body surface or into the fatty layer or deforms and displaces surrounding structures important data with reference to the lesion is made available In the regions of the joints soft tissue neoplasms may be visualized as extracapsular or intracapsular masses

The most common periarticular neoplasms are xanthomas synoviomas and angiomas The roentgen examination is of value in outlining the size location and density of the growth although the nature of the lesion can not in many instances be determined accurately by roentgenologic methods A cyst of the lateral meniscus of the knee may be demonstrable as a sharply outlined prominence at the lateral margin of the joint and differs from synovitis which is characterized by a bilateral bulging with fluid in the suprapatellar pouch A cyst in the popliteal region is visualized as a rounded area of uniform soft tissue density through the

lobulations and irregular mottled patches which are more radiant than normal and through which are scattered areas of soft tissue density due to giant cells spindle cells and fibrous strands which may occur in the mass The dermoids are round or oval sharply defined frequently show a rim of slightly increased density surrounding the area of rarefaction in their central portion and in many instances contain a small *fragment of tooth or bone* *In the chest, dermoids occur particularly in* the anterior mediastinum The lipomas liposarcomas and dermoids may appear more dense than the air filled lungs when they occur in the chest cavity Confusion with neurofibroma may result in mistaken diagnosis Laryngeal diverticulum may resemble lipoma in some instances Usually however lipomas present a very characteristic appearance and diagnosis may be made with a high degree of accuracy from soft tissue roentgenograms Large glands abscesses and tumors of the neck and axilla are demonstrable and the size and nature of the lesion may be determined in many instances

Soft tissue tumors of the neck are visualized on the roentgenogram as areas of increased density and localized prominence of the tissues Masses of glands in the lymphomas tuberculosis and leukemia are usually demonstrable roentgenographically and may be unilateral or bilateral Calcifications may occur in tuberculous lymphadenopathy (Fig 309) the calcific deposits being discrete or conglomerate irregular in outline and often arranged in a linear fashion extending from the angle of the jaw to the supraclavicular or axillary region Metastatic neoplasm involving the glands may cause masses of varying size in the neck and *supraclavicular fossa particularly in carcinoma of the breast* and stomach The size and density of the shadows visualized on the roentgenogram are not characteristic Changes in the size of the mass after radiation therapy may be demonstrated by roentgen methods Meningocele of the cervical and occipital region may produce soft tissue masses in the neck These are rounded and may be small or large some attaining great proportions While the site and shape of the mass usually facilitate diagnosis air injection into the lumbar spinal canal may be necessary to prove the exact nature of the lesion

Cutting injuries to the neck result in marked swelling of the soft tissues due to hemorrhage and edema and the presence of air in the tissues along the line of incision Attempted suicide by cutting the throat or injuries with homicidal intent are the usual cause of these traumatisms Roentgen studies may be of aid in determining the extent of the damage to the soft tissues and to observe the progress of the healing (Fig 310)

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SAMUELS F Radiologic Diagnosi of Lipomas Brit J Rad *20* 55–57 1947

SUBCUTANEOUS EMPHYSEMA

Subcutaneous emphysema is of relatively frequent occurrence *With the* greater incidence of automobile accidents and similar types of traumatisms the condition has shown an increasing incidence in recent years It may be caused by any moderate or severe injury to the chest and neck and occurs also after severe coughing bronchoscopy tracheotomy and infections of the cervical region It is especially prone to develop subsequent to a retropharyngeal absces

Section VII

THE HEART AND GREAT VESSELS

INTRODUCTION AND METHODS OF EXAMINATION

THE heart and great vessels are clearly visualized roentgenographically because of the excellent contrast afforded by the air filled lungs which lie adjacent to these structures. This permits of observation and measurement of changes in the size, shape and position of the cardiac and vascular structures. The individual cardiac chambers may be outlined and their pulsations studied. The roentgen examination is important in the study of the physiology of the heart as well as in the diagnosis of the pathologic conditions which affect this organ. Roentgen studies have proven of value in the early detection of cardiac lesions and in observation of the heart which has been affected by disease both for prognosis

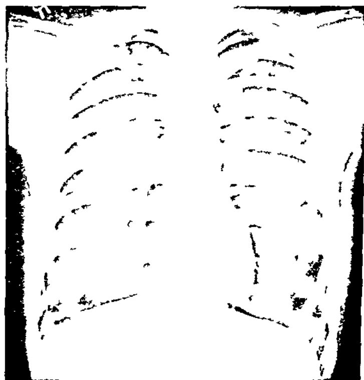


FIG. [illegible].—Teleoroentgenogram of the Heart and Great Vessels on Full Inspiration.

On full inspiration the diaphragm is depressed and the heart is shifted, occupying a more vertical position. The apex of the heart is clearly visible. The teleoroentgenogram in full inspiration does not give an accurate measurement of the size of the heart and should not be used for cardiac measurements. Compare with Fig. [illegible].

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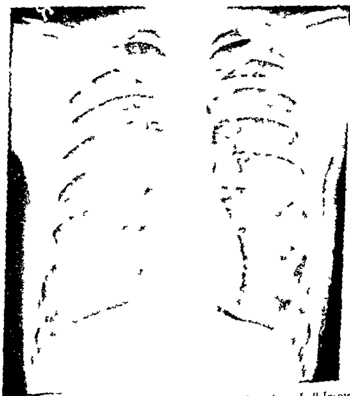


Fig. 332 — Teleoroentgenogram of the Heart and Great Vessels on Full Inspiration. On full inspiration the diaphragm is depressed and the heart is shifted occupying a more vertical position. The apex of the heart is clearly visible. The teleroentgenogram in full inspiration does not give an accurate measurement of the size of the heart and should not be used for cardiac measurements. Compare with Fig. 333.

the film and 2) by increasing the target film distance Since the heart lies in the anterior portion of the chest the first objective is obtained by the use of the posteroanterior projection the roentgen study being made with the patient facing the cassette or fluoroscopic screen The target film distance routinely used in the study of the heart is 6 to 7 feet which minimizes the magnification to less than 10 per cent In many clinics the 7 foot distance is the accepted

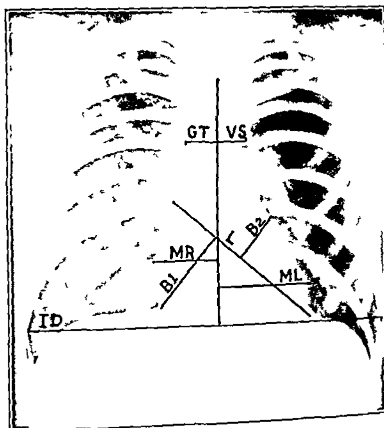


Fig 4 Measurement of the Heart on the Teleoroentgenogram

MR	Mid line to right border
ML	Mid line to left border
TD (ML + MR)	Transverse Diameter of Heart
L	Long Diameter of Heart
B = B1 + B2	Broad Diameter of Heart
GT	Diameter of Aortic Arch
ID	Internal Diameter of the Chest

standard A small focal spot roentgen tube and short exposure time ¼ second or less are of value to produce the greatest sharpness of outline With modern apparatus exposures as short as 1/? th of a second or less are possible The patient stands with the sternum in contact with the film holder and the target is focused at the 5th 6th dorsal vertebra The patient is instructed to stop breathing in the middle of a quiet respiration in order to eliminate changes in the heart position and size due to forced inspiration or expiration (Fig 33?) A full breath by depressing the diaphragm and shifting the position of the

heart may result in an error of 2 0 cm or more in the transverse measurements Fluoroscopy must always be used in combination with the teleoroentgenogram to permit of accurate identification of the various chambers of the heart The 6 foot film has the advantages of supplying a permanent record which may be studied by more than one observer and being available for comparison if subsequent observations are made (Fig 334) It may also reveal abnormalities in the lungs spine bony thorax mediastinum and diaphragm

Theoretical Transverse Diameters of Heart Silhouette for Various Heights and Weights

Table for Determining the Per Cent Deviation from Average

Fig 335 —Chart of theoretical transverse diameters of the heart silhouette for various heights and weights with table for determining the per cent deviation from the average

Orthodiagraphy —In orthodiagraphy fluoroscopy alone is used The roentgen tube must be centered accurately with relation to the patient and the shutters closed so that only a very small beam of rays is emitted The screen is fixed firmly in position against the front of the chest With a soft pencil the margins of the silhouette of the heart and great vessels are marked by a series of dots on the glass the roentgen tube being moved about 1 to 2 centimeters between each dot These markings are then transferred to tracing paper and connected by a continuous line (Fig 338) The margins of the chest wall the levels of the

8

leaves of the diaphragm and the mid line are also marked The observations are made during quiet respiration and the patient must remain immobile throughout the examination There are modifications of the equipment which permit of making the markings directly on paper or a roentgen film This method of study is time-consuming and entails considerable roentgen exposure of both the patient and observer particularly if tracings are made in the oblique as well a

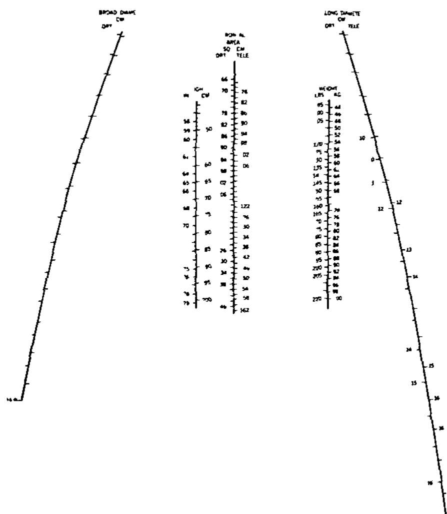


FIG 356 —The Predicted Area from the Height and Weight of the Patient and the Actual Area from the Long and Broad Diameters as Determined by Roentgen Methods Nomogram

The values for the actual or predicted area are read at the point at which a straight line extending *from the* long and broad diameters (or the height and weight) intersects the cardiac area scale The orthodiagram values (orth) are on *the* left and the teleroentgenogram values (tele) are on the right

$A = \pi/4\ L \times B$ for the orthodiagram and teleoroentgenogram

A area of heart

L *length* of heart

B broad diameter of heart

Fig. 337 — Nomogram [illegible]

and [illegible]

[illegible]

Fig. 338 — [illegible] of the Cardi[illegible] Silhouette [illegible] Orth[illegible]

MR	[illegible]
ML	[illegible]
TD (ML + MR)	[illegible]
L	Long d[illegible] of the heart
B (B + B)	Br[illegible] of the heart
CV	[illegible]
ID	Internal [illegible] of the chest

studies are best performed with the patient seated or standing. The vein in the region of the elbow is exposed and a needle of large caliber usually No 14 bore is inserted under aseptic precautions. Forty cubic centimeters of 70 per cent diodrast solution is injected rapidly, the time for the injection being 2 seconds or less. Various positions are essential for visualization of the different chambers of the heart and the great vessels. With one injection and the two roentgenograms provided by the ordinary stereoscopic cassette shifter it is usually possible to visualize the right side of the heart and the pulmonary arterial tree in practically all instances and the left cardiac chambers and the thoracic aorta in approximately 75 per cent of the cases. Thus with one or in some instances two injections the study may be completed satisfactorily with the apparatus available in most roentgen laboratories. By the use of special cassette changers which



Fig 344 Normal Angiocardiogram
A and B Conventional roentgenograms frontal and left oblique projections

enable the technician to shift the films quickly and take a series of 6 or 8 exposures in rapid succession the examination may be carried out with much better results. Photofluorographic apparatus which is now in widespread use in survey studies of the chest has been utilized to obtain a series of angiocardiograms. Either 35 mm or 70 mm film may be used and as many films as desired may be exposed rapidly with the photoroentgen machine and the Morgan timer. The objection to this method has been that the resulting roentgenograms are small. However magnification apparatus is available which enables the observer to visualize the various portions of the heart and great vessels in satisfactory detail. Roll film is also being utilized. The patient must be completely immobilized, suspend respiration and cooperate during the entire examination as blurring, under exposure or other technical faults make satisfactory study impossible. The arm to tongue and arm to lung circulation times are determined by the ether and Decholin methods prior to the examination in order to permit of accurate timing

has been used successfully in a great variety of cardiovascular diseases and has made earlier and more accurate diagnosis possible in many instances Congenital rheumatic syphilitic hypertensive arteriosclerotic and pulmonary heart disease have been studied as have also chronic constrictive pericarditis and pericardial effusion It is a method of great value in the study of cases of the superior vena cava syndrome to demonstrate the site of an arteriovenous fistula of the subclavian vessels and in the differentiation of aortic pulmonary artery and cardiac aneurysms although it must be stressed that the dye may not enter the aneurysm In congenital heart disease it is important in the diagnosis of dextrocardia and intracardiac shunts One of the greatest fields of usefulness is in cases of developmental anomalies which are amenable to surgery and in this group fall pulmonic stenosis coarctation of the aorta and patent ductus arteriosus Angiocardiography is of value in the study of neoplasms of the lung and mediastinum and arteriovenous aneurysms within the pulmonary fields

There has been considerable confusion and difference of opinion among radiologists regarding the analysis of the segment of the left cardiac contour which lies between the aortic knob and the left ventricle in the sagittal roentgenogram This has been due in part to lack of uniformity in nomenclature "Pulmonic conus" is properly used to designate the portion of the right ventricle immediately below the pulmonary valve or the outflow tract However the term has been applied by many to the base of the pulmonary artery which is in reality the pulmonary sinus The pulmonary valve is situated well within the cardiac contour hence the pulmonic conus does not reach the cardiac border The middle left segment of the heart outlined on the sagittal roentgenogram has been proven by angiocardiography to be composed of the pulmonary artery cephalad with a portion of the left auricular appendage or auricle caudad On the right side the cardiac outline is made up of the right auricle It has also been shown by angiocardiographic study that the right ventricle does not enter into the cardiac silhouette in the sagittal projection Therefore the size of the right ventricle cannot be estimated from routine roentgenograms

In the mitral heart the middle segment of the left cardiac contour is divided into two arcs the upper immediately caudad to the aortic knob being formed by the main pulmonary artery or its left branch and the one directly below comprising the left auricle and or auricular appendage The pulmonic conus is always found well within the cardiac silhouette and in no instance does it contribute to the formation of the left cardiac border The left atrium forms the upper part of the right border of the heart The prominence of the middle segment on the right is not due to the right ventricle but rather to an enlarged left auricle In the presence of very marked enlargement of the left auricle this chamber may extend far beyond the right atrium and form the greater portion of the cardiac silhouette on the right side Rarely the enlarged left atrium extends to the left and it then forms a portion of the cardiac border on that side In mitral stenosis and insufficiency the heart is triangular in shape due to the prominence of the right auricular and left ventricular contours below and the convexity of the pulmonary arc above The right cardiac margin exhibits the double contour so frequently seen the upper curve being produced by the enlarged left atrium and the lower by the right atrium On the left side the heart border presents four curves From above downward these are the aorta the dilated pulmonary artery the enlarged left auricle and the hypertrophied and displaced left ventricle In the right

ventricular premature beats chronic auricular fibrillation recent coronary occlusion subacute bacterial endocarditis and blood dyscrasias with bleeding tendencies Advanced cardiac failure uremia pulmonary insufficiency and old age have not been considered *contraindications* by most observers The procedure must be carried out with a reasonable degree of rapidity *in order to avoid excessive* exposure to *x* ray of the observer or the patient

Congenital heart disease is often difficult to diagnose clinically because of the absence of pathognomonic signs and symptoms and also since a multiplicity of defects may exist in the same case In view of the recent great advances in thoracic surgery *early and more* accurate diagnosis is imperative In pulmonary stenosis a lower systolic pressure is found *in the pulmonary arteries than in the right ventricle* In the tetralogy of Fallot the diagnosis is made *by inference rather than by* direct evidence The catheter may pass through the pulmonary valve and pulmonic stenosis can be demonstrated by pressure tracings If the systolic pressure in an artery of the systemic system is the same as that in the right ventricle dextroposition of the aorta is present that is the aorta overrides both *the right and left ventricles and these chambers act as a common chamber in* function even though they may be divided by *a partial or total septum* In some cases the catheter passes from the right ventricle directly to the aorta proving the presence of dextroposition of the aorta In this instance the systolic pressures in the aorta and right ventricle are found to be identical confirming the existence of this anomaly If the catheter does not enter the pulmonary artery pulmonary stenosis is indicated by *the finding of high pressure in the right ventricle* and a *reduction* of the pulmonary vascular markings on the roentgenogram Eisenmenger s complex is similar to the tetralogy of Fallot except that *there is no pulmonic stenosis The diagnosis by venous catheterization* depends on finding systolic pressures in a systemic artery and the right auricle indicative of dextroposition of the aorta and in the right ventricle and the pulmonary artery showing the absence of *pulmonary stenosis In patent ductus arteriosus and aortic septal defects* samples of blood from the pulmonary artery and right ventricle prove entrance of arterial blood into the pulmonary artery The withdrawal of blood from the right auricle and right ventricular chamber reveals the presence of arterial blood mixtures in the right ventricle in ventricular septal defects and patent ductus arteriosus with *pulmonic insufficiency* The demonstration of arterial blood in *the right atrium* is indicative of an *atrial septal defect* Multiple blood samples withdrawn from the individual chambers of the heart and the great vessels may be examined chemically and the percentage of oxygen and other gases determined with accuracy Variations from the normal standards reveal whether abnormal blood mixtures are present Since venous catheterization is carried out under the guidance *of the radiologist* it is essential that he be familiar with the *chemical* and laboratory manifestations of *the various anomalies*

ADDITIONAL READING

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THE NORMAL HEART AND ITS MEASUREMENTS

The heart shadow as visualized in the sagittal projection is comprised of a series of arcs or curves which represent the margin of the various chambers and

more accurate procedure is to compare the transverse diameter as measured with standards of normal according to the height and weight of the individual, age and sex having been found relatively unimportant in this respect. This has proven accurate to approximately 90 per cent and is satisfactory for all practical purposes (see Fig. 335). If the heart is less than 10 per cent above the normal accepted standards as determined on the teleoroentgenogram or orthodiagram, it is considered within normal limits, while variations of 15 per cent or more greater than the normal measurements are considered abnormal. This method affords a basis for comparison in subsequent examinations as teleoroentgenograms can be reproduced in different clinics and at various times. Other measurements and computations may be made to determine the cardiac area, thickness of the left ventricular wall, and the heart volume. These are not in general use as there are objections from the viewpoint of practicality. Ungerleider utilizes a method which makes it possible to determine the frontal area of the heart by the use of a nomogram. The long diameter of the heart (L) and the diameter of the base of the heart (B) are multiplied by the factor $\frac{\pi}{4}$, the formula for computing the area (A) being $A = \frac{\pi}{4} L \times B$. The area of the heart is correlated with the weight and height of the patient and is predicted from the teleoroentgenogram and the nomogram (Fig. 336). The frontal aortic arch silhouette is determined in the same manner from the nomogram, a correction factor for age being necessary in the determination of the aortic diameter (Fig. 337). The supracardiac area in the teleoroentgenogram is measured at the level of the second interspace anteriorly. In some clinics the greatest width to the right of the mid line is added to the greatest width to the left of the mid line and is used instead of a single straight line. The superior limit of normal for this measurement is ? 0 cm. in the adult, measurements greater than this being indicative of widening or dilatation of the aorta.

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quently shows linear or lunate shaped areas of calcification particularly in the region of the knob In advanced pulmonary tuberculosis Addison s di ease and other conditions as ociated with marked wasting there is a decrease in the size of the heart This diminution is not uniform however, the left ventricle becoming relatively smaller than the right and resulting in a distinct change in the contour as well as the size of the cardiac shadow The shape of the heart tends to conform to the habitus of the individual In the asthenic type of person the heart occupies a vertical position in a long narrow chest with a low flat diaphragm (Fig 347) The pulmonary artery conus portion of the left heart border is straight or slightly convex and extends from the aortic knob for a considerable distance downward The left auricular segment is small and the left

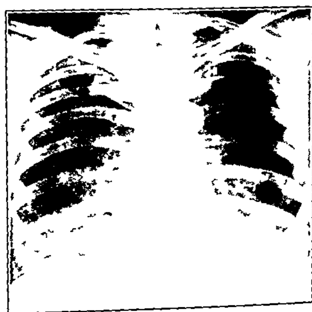


Fig 346 – The Heart in the Hypersthenic Individual

In the hypersthenic or ches e individual the heart lies transversely and the diaphra m is high The left ventricle forms alm st the entire l ft cardiac border and the pulmonary conus artery egm nt i small In obesity the high position of the diaphragm causes the heart to assume a transv r e po ition and the heart may appear enlarged The apparent enlargement a s iated with ob sity mus be taken into account in the meas rement of the heart in this type of per on

ventricular border comprises the lower half or less of the l ft margin of the cardiac silhouette In the hypersthenic individual the heart lies transversely and the diaphragm is in a relatively high position (Fig 346) The left ventricle forms the greater portion of the left cardiac outline and the pulmonary artery conus segment is mall and concave In the sthenic type of person the heart is intermediate between these two form The heart in females is slightly smaller than in the male the variation being approximately 5 per cent However this is within the limits of error in the methods of measurement in common use and hence is not of practical importance Respiratory excursions of the diaphragm result in variations in the hape of the heart On inspiration the heart is elon

gated and narrower on expiration the converse is true the heart becoming shorter and wider Similarly in pregnancy ascites and large abdominal tumors which produce an elevation of the diaphragm the heart become shorter and wider Abnormalities of position of the heart are usually due to extracardiac condition pulmonary lesions being the commonest cause Thus the heart is displaced in atelectasis pleural effusion tension pneumothorax and fibrosis of the lung in old tuberculosis

Individuals with marked obesity may present difficulties in the accurate determination of cardiac size The diaphragms are elevated and the heart assumes a transverse position This results in a short broad cardiac silhouette with a widened aortic loop The left apex and heart border may be located only

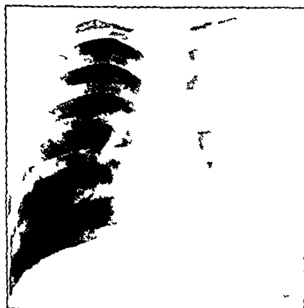


Fig 347 — The Heart in the Asthenic Type of Individual

In persons of the asthenic or ptotic type the heart occupies a vertical position The diaphragms are low and the interspaces are wide

with difficulty because of the poor contrast between the heart and the surrounding structures A triangular or quadrilateral collection of fatty tissue the epicardial fat pad is present between the pericardial and diaphragmatic surfaces in many cases and serves to increase further the difficulties of localizing the heart borders Careful fluoroscopy with a small shutter opening is helpful in localizing the margins and to locate the individual chambers of the heart Roentgenograms with the Bucky diaphragm and a high kilovoltage technique may be essential in extreme cases There is rarely actual cardiac hypertrophy in obesity, the changes being apparent rather than real Obesity is apt to be associated with hypertension in which instance there is usually cardiac hypertrophy to the left in the region of the ventricle with dilatation of the ascending aorta. In tuberculosis advanced malignancy, and other wasting diseases the

heart shadow appears small and presents straight bo d rs most probably due to the general lo s of body tissues in these conditions Emphysema is frequently associated with a heart which is small on teleoroentgenographic measurement because of the increased diameter of the chest and low position of the diaphragm Cardiac hypertrophy is rarely present with emphysema In pneumoconiosis there is prominence of the pulmonary artery shadow and straightening of the left heart border In youn adults of the late teen age group there is frequently straightening or slight prominence of the left mid portion of the heart border which may easily be confused with the mitral configuration particularly if the roentgenogram has been made in full inspiration A similar

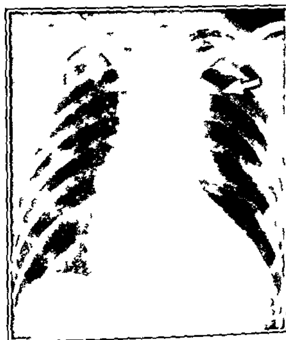


Fig 548 Enlarged Heart Leutic Heart Disease

There is cardiac hypertrophy with enlargement to the left in the region of the ventricle The aorti knob i prominent (white arrow) and the aorta is dilated The patient had luetic heart disease with aortic re urgitation

change may occur in hyperthyroidi m Deformities of the chest result in a marked displacement and rotation of the heart with tortuosity and di tortion of the aorta Hypertrophy often very marked in degree ma also occur With kyphosis and scoliosis the enlargement ma be apparent rather than real By rotation of the patient into the oblique and lateral positions a more accurate estimation of the cardiac size and contour may be obtained In marked kyphosis of the upper dorsal spine as seen in advanced tuberculo is of the spine congenital anomalies or compre sion fractures the angulation and compre ion of the ao ta may result in cardiac hypertrophy, decompen ation and death

CARDIAC ENLARGEMENT

Enlargement of the heart may involve the ventricles the auricles or both set of chambers simultaneou ly While combined forms of hypertrophy are common

close relation to the heart or extend into the heart wall so that it is not always possible to determine accurately whether the deposits are limited to the pericardium or actually involve the heart. Careful roentgen techniques are essential to the demonstration of intracardiac calcifications (Figs 367–370). Roentgenoscopy must be carried out by a careful and trained observer as the calcific deposits are easily overlooked unless particular care is exercised in every case. Complete dark adaptation is absolutely necessary and 20 to 30 minutes should be spent in darkness prior to the study. The calcific deposits are best visualized by peripheral vision and by looking through the heart shadow.



Fig. 6.—Calcification of the Aorta, the Valves of the Heart and the Annulus Fibrosus. Lateral projection of the chest. There is marked dilatation of the ascending and transverse portions of the aorta with calcification of the aortic wall. There is calcification of the aortic ring (white arrow) and the annulus fibrosus (black arrow). The origin of the aorta deep in the heart shadow is well illustrated.

A fine focus tube and the highest quality fluoroscopic screen are essential. High kilovoltage is used and the roentgenoscopic aperture must be very small. The patient is turned slightly obliquely to avoid overlapping of the spine; the degree of rotation varying with each individual. After the calcific shadow has been localized and its movement studied thoroughly, a skin pencil is used to mark directly on the patient's body the optimum site and projections to demonstrate the calcifications. Roentgenograms are made with a small cone almost in con

tact with the patient to shorten the exposure time as much as possible A 500 milliamperage roentgen generator with exposures of $\frac{1}{20}$th second are best although $\frac{1}{10}$th or $\frac{1}{5}$th second at 200 milliamperes may prove satisfactory except in very heavy individuals The Bucky diaphragm usually cannot be used because of the longer exposures required This also applies to kymography and body section roentgenography except in thin individuals with extensive large calcifications The examination *requires a cooperative patient who can remain motionless* and suspend respiration completely during roentgenoscopy and the making of the exposure Fluoroscopic studies are essential to determine the presence

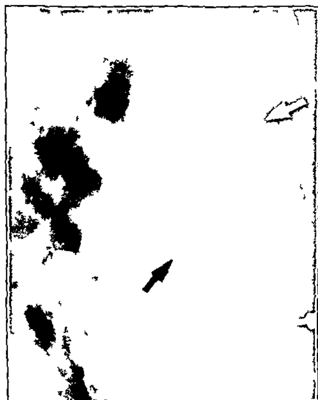


Fig 368 —Intracardiac Calcification Calcification of the Aortic Ring and the Coronary Artery

Lateral view The ascending aorta is markedly calcified (upper white arrow) There is extensive calcification of the aortic ring (black arrow) There are two parallel curvilinear areas of calcific density faintly visible close to the surface of the heart (lower white arrow) calcification of the coronary artery

nature and localization of intracardiac calcifications and are always carried out first Roentgenograms check the observations make a permanent record of the findings and are important for the detailed study of the lungs ribs mediastinum and spine

Valvular Calcification —The mitral and aortic valves are the most frequently involved the tricuspid and pulmonic valves only rarely being affected

Approximately 10 per cent of patients with rheumatic mitral stenosis have calcification in the mitral valve and about 90 per cent of those with aortic stenosis present calcification in the aortic valve Calcific shadows are recognized as small, irregular densities which move synchronously with the heart (Fig 36ɩ) The calcified mitral valve is nearer the apex of the heart while the aortic valve lies clo er to the base due to the fact that in mitral disease the greater proportion of the heart outline is made up of the dilated auricles while in aortic steno is the hypertrophied ventricles comprise the major part of the cardiac shadow The calcified valves are best visualized in the right anterior oblique position The optimum projection for differentiating between the mitral and aortic valves is the left anterior oblique the mitral valve being in the posterior and inferior



Fig 69 —Calcification of the Mitral Valve and Annulus Fibrosus

A Intracardiac calcification i difficult to demonstrate on routine roentgeno rams (black arro)

B The al the shado was b rved fluoroscopically and showed the chara teristi dancin motion On spot films the calcification of the mitral valve has the shape of an inverted (white arrow) The cal ific deposits in the annulus fibrosus are broad irregular and mottled (bla k arro)

third of the heart shadow and the aortic valve more anterio ly The calcified valves move up and down and from side to side during both sy tole and dia tole In some in tances the motion is circular and the excursion may be as much a 1 to 2 cm in extent During sy tole the movement i apparently downward The amplitude is greater than that of the heart border The calcific deposits are punctate or conglomerate lie deep within the heart and the motion is u ually de cribed as dancing in type With calcification of both the aortic and mitral valves there may be seesaw movement of the two valves

Calcification of the Mitral Annulus Fibrosus —Calcification of the mitral ring or annulus fibrosu is commonly seen in older people It i characterized by large dense masses which may be mottled or of homogeneous den ity and have the hape of a segment of a circle while calcified valves are apt to be irregular and nodular (Fig 369) The movements are gentle and wave like during sy tole

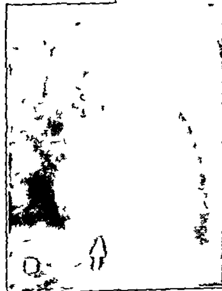
may pulsate or be motionless Occasionally there is a paradoxical excursion with retraction during diastole and expansion in systole (Fig 363 p 470)

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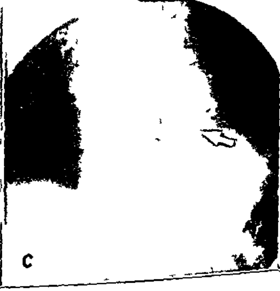


Fig 370 – Myocardial Calcification

A Sagittal projection The calcification is only very faintly visualized (black arrow)

B Lateral view The calcification shows deep caudad extension (white arrow)

C Spot film with a small cone centered over the calcific area The film is greatly over exposed for the detail of the lungs and heart The calcification forms a crescentic shadow slightly above the diaphragm (white arrow)

position is the most common and is associated with small defects about 0.5 cm in width on the posterior and left lateral aspects of the esophagus slightly above the level of the aortic arch. These are smaller than the defect produced by a posterior right aortic arch. A small notch may also be present on the right posterolateral aspect of the esophagus but is smaller in extent. If the anomalous vessel lies anteriorly to the esophagus and behind the trachea the defect is visualized on the anterior surface of the esophagus. With an anomalous vessel which passes in front of the trachea there is no demonstrable defect or constriction of the trachea. In the study of the esophagus barium mixtures of paste like consistency are commonly used. To opacify the trachea iodized oil is most satisfactory and in some instances the iodized oil preparations may be preferable for study of the esophagus also (Figs 388, 389).

Transposition of the Great Vessels.—There are numerous types of malposition of the great vessels. In one form the aorta and pulmonary artery are transposed, the former lying anteriorly and communicating with the right ventricle while the latter is posterior and communicates with the left ventricle. This anomaly results from counterclockwise growth of the primordia of the septum aorticum and is concomitant with situs inversus. The two great arteries may arise from a common ventricle, either the right or the left. The aorta may override a defective interventricular septal defect and communicate with both ventricles. Either or both of the transposed great arteries may be normal in caliber, decreased in size or enlarged. They may lie laterally to each other or with the aorta ventral to the pulmonary artery. The positions of the great veins may be transposed and show variations similar to those occurring in the arteries. The roentgen findings are dependent on the type of anomaly. In transposition of the arterial trunks and congenital anomalies of the innominate arteries the heart is usually markedly enlarged and globular in shape. The left border of the heart is concave as in the tetralogy of Fallot due to absence of the shadow of the pulmonary artery conus segment. The supracardiac area may be decreased in width, widened or apparently normal. Angiocardiographic studies are essential for the roentgen demonstration of these transpositions.

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Section VIII

THE AORTA

THE ascending aorta on the sagittal roentgenogram forms a smooth rounded shadow slightly lateral to the border of the spine and extending cephalad from the superior margin of the right auricle The superior vena cava merges with the upper portion of the ascending aorta The transverse portion of the aortic arch lies slightly below the level of the sternal notch It extends vertically and posteriorly to the aortic knob which forms a smooth rounded projection or arc



Fig 90 — Marked Sclerosis of the Aorta

Lateral projection The ascending aorta is markedly calcified (white arrow) The descending aorta is dilated and sclerotic (black arrow)

LEGEND FOR FIGURE 391

A Sagittal projection The aorta is widened and tortuous (white arrows) The aortic knob is markedly prominent (black arrow) The descending thoracic aorta is widened *The heart shadow shows prominence to the left in the region of the ventricle*

B Oblique projection The shadow of the aorta appears distinctly narrow (black arrows The aortic knob is prominent (white arrow) Sagittal and oblique projections are important *in the differential diagnosis of arteriosclerosis of the aorta and luetic aortitis*

In arteriosclerosis the aorta appears widened in the anteroposterior view and narrow in the lateral or oblique projection while in luetic aortitis there is widening of the aorta in both projections

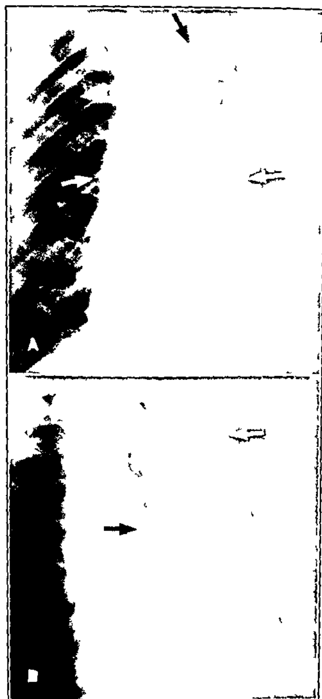


Fig 391 Tortuosity of the Aorta in Arteri sclerosis

(See opposite page for legend)

adjacent to the left margin of the manubrium sterni The descending portion of the aorta is visualized slightly laterally to the left border of the spine in its superior portion overlapping the vertebral column as it extends downward and is often visible through the heart shadow In the right anterior oblique projection the anterior portion of the supracardiac shadow is made up of the ascending aorta with the innominate artery extending above the aorta and the superior vena cava The ascending and descending portions of the aorta are divided by the trachea and the right main bronchus The descending aorta is visualized between the heart and the spine and on inspiration the increased radiance in the posterior mediastinum may make it possible to determine the size and position of this portion of the aorta In the left anterior oblique projection the entire aorta is well outlined The radiant area between the ascending and descending portions

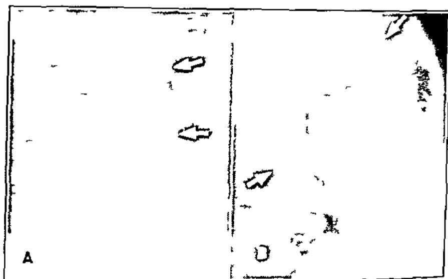


Fig 597 —Calcification of the Aorta

A Sagittal projection The aorta is widened tortuous and sclerotic with extensive calcification of its walls (white arrows)

B Lateral view The sclerotic aorta is visualized throughout its entire extent

of the aorta is formed by the trachea bronchi and surrounding lung tissue This is termed the aortic window and lies directly below the transverse portion of the aorta

Elongation and Widening of the Aorta —The aorta is fixed at two points at the base of the heart and the diaphragm Because of the elastica in its wall the aorta may vary in length and caliber These changes occur in association with increased arterial pressure aortic insufficiency arteriosclerosis and luetic aortitis Elongation is usually accompanied by dilatation and may be localized to one segment of the vessel or involve its entire extent With elongation the right side of the aortic shadow the ascending portion extends to a higher point than normally the arch lying at or above the level of the clavicles The aortic knob is prominent and extends cephalad and to the left The shadow of the descending aorta is widened There may be displacement of the trachea to the

Jackson and Newburg examined 66 patients with syphilitic aortitis and demonstrated linear calcification of the ascending portion of the aorta in 22 7 per cent They also made studies by roentgen methods in 62 autopsy cases of severe arteriosclerosis of the aorta and found only 3 2 per cent to have calcium in the ascending aorta As a rule syphilitic aortitis is most evident in the ascending aorta near its point of origin When calcification is present it indicates that the disease is advanced and of long standing It is not certain whether the

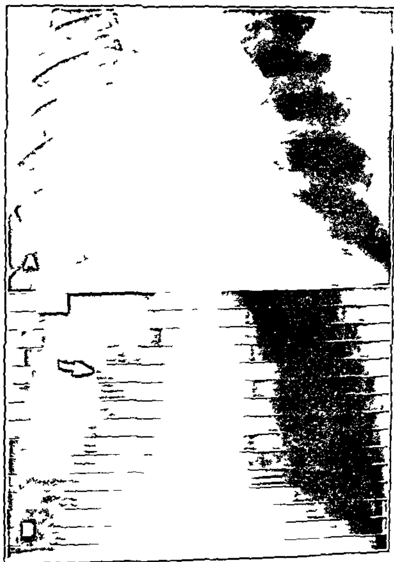


Fig 594 — Aortitis

A Sagittal projection The supracardiac area is markedly widened to the right and left due to marked dilatation of the aorta The aortic knob is not prominent Diffuse dilatation of the aorta is characteristic of luetic aortitis

B Kymogram The pulsations of the aorta are increased in amplitude The ascending aorta is visualized throughout its entire extent and extends beyond the shadow of the superior vena cava (white arrow)

wasting diseases mitral stenosis and interatrial septal defects A diffuse decrease in the size of the aorta may occur as a congenital anomaly In coarctation of the aorta there is usually a narrowing below the point of coarctation

Aneurysm of the Thoracic Aorta *(Figs 396–404)*—While most aneurysms of the aorta are luetic in origin a small but definite number (approximately 10 per cent) are due to arteriosclerosis trauma congenital anomalies and inflammatory changes The commonest type is the saccular and the aortic arch is the *most frequent site* The fusiform aneurysm is usually seen in the descending thoracic aorta and the abdominal aorta and is much less common Not all aneurysms are demonstrable by roentgen methods those in the region of the



Fig 396 —Aneurysm of the Aorta

A Sagittal roentgenogram with the Bucky diaphragm The aneurysm forms a rounded sharply defined area of increased density in the region of the aortic knob and the superior portion of the descending thoracic aorta (white arrow)

B Lateral roentgenogram The size and location of the aneurysm are more clearly demonstrated than in the sagittal projection (white arrow)

sinus of Valsalva and small lesions extending from the aortic arch often being overlooked during even the most careful studies The aneurysm usually produces a smoothly outlined sharply defined area of density lying in close relation to and not being separable from the shadow of the aorta in any projection The aneurysm may present a narrow or a broad base While usually single multiple lesions may occur The size varies from small to very large and the latter may occupy practically the entire lung field Smaller daughter sacs may project from the main mass Expansile pulsation is usually described as characteristic of aneurysm of the aorta Many do not pulsate because of the thickness of the wall or organization within the lumen Similarly many mediastinal and pulmonary tumors lying in close relation to the aorta appear to show expansile pulsation which is due to transmission Circular or oval depositions of calcium frequently

occur in concentric layers or as linear densities at the peripheral portions of the lesion The shape of the mass may be ovoid rounded or globular The aneurysm usually develops along the line of the main axis of the aorta although there are many exceptions to this rule The heart may or may not be enlarged in association with aortic aneurysms Displacement and compression of the trachea and esophagus are frequently present Obstruction of a bronchus may produce atelectasis and bronchiectasis of varying degrees There may be erosion of

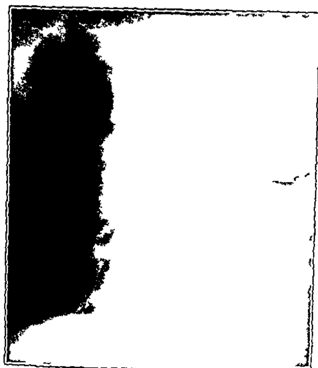


Fig 397 —Aneurysm of the Descending Thor A rt th Aneurysmal Dilatation of the Entire Aorta

The supracardiac area is increased markedly in width to the l ft and l ghtly t the right On ertgenoscopy there was expansile pulsation in the aneury m (wh r w)

the ribs sternum or spine these changes at times not being demonstrable on the rout ne chest film and requiring special exposures with the Bucky diaphragm or laminograph The aortic window is obliterated in lesions of the arch and up de cending aorta Roentgenoscopy kymography and angiocardiography are important aids in the study of aortic aneurysms

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Aneurysms of the Innominate Artery —These aneurysms usually extend upward into the root of the neck beneath the sternocleidomastoid muscle and are manifested by an area of density in this region or widening of the shadow of the superior mediastinum The aortic knob may be displaced downward or laterally Erosion of the clavicle rib sternum or vertebræ may occur and is of great diagnostic import Differential diagnosis must include a large number of conditions chief of which are thyroid tumors lymphoma, thymoma dermoid tuberculous gland carcinoma of the lung and tuberculous abscess of the spine

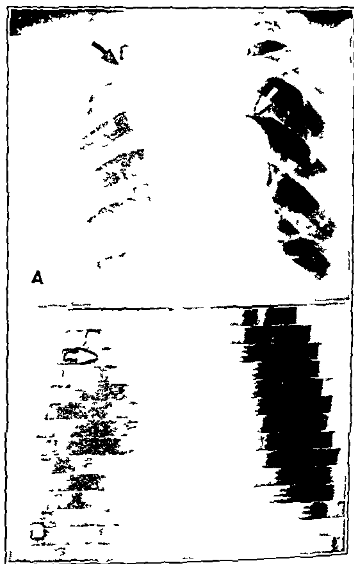


FIG 398 —Aneurysm of the Ascending Aorta

A There is round d ft ti sue density in the right supra-cardiac area (black arrow) The margin f th area re sm oth and sharply defined There is cal ification in the regi n of the ar h of the a rt (white arrow)

B Kymogram Expan ile pul ations are demonstrable at the mar ins of the aneurysm (white arr)

Dissecting Aneurysm of the Aorta —Dissecting aneurysm of the aorta has been known to clinicians and pathologists for many years and the literature contains frequent references to this most interesting condition. However, the number of cases diagnosed correctly during life still remains extremely small. While relatively uncommon, this lesion is nevertheless of great clinical significance. In many instances the dissection of the aorta develops with dramatic suddenness and is manifested by excruciating pain, collapse and sudden death. The symptoms may closely simulate coronary disease, embolism or rupture of the heart, and errors in diagnosis are therefore very common. The [illegible] are often misleading and confusing. Since prompt and accurate diagnosis [illegible] the utmost importance from the standpoint of both therapy and prognosis, the important clinical and roentgen manifestations which are of [illegible] the diagnosis must be clearly understood.



FIG. 799 —*Aortic Aneurysm with Erosion of the Ribs [illegible]*

A Sagittal roentgenogram. The aortic aneurysm forms a [illegible] in the left upper lung field. Roentgenoscopy revealed extensive pulsation of the aneurysm. The [illegible] shadow is small.

B Over-exposed film with the Bucky diaphragm. The shadow of the aneurysm [illegible] partially obliterated. There is extensive destruction of the left lateral margin of the upper dorsal vertebrae (black arrow) and the left upper ribs (white arrows).

It is essential in the complete study of an aortic aneurysm to [illegible] studies of the ribs, spine and sternum *in addition to the roentgenograms of the [illegible]*

[illegible]ology —The incidence of dissecting aneurysm of the aorta varies widely in [illegible] series of reported cases. In hospital and private practice the number is [illegible] smaller than autopsy statistics indicate. This is owing to the fact that the lesion frequently occurs in persons who have had no previous complaints and death occurred suddenly. Hence the studies in this condition are more often [illegible] out by the coroner and medical examiner than by the clinician. According

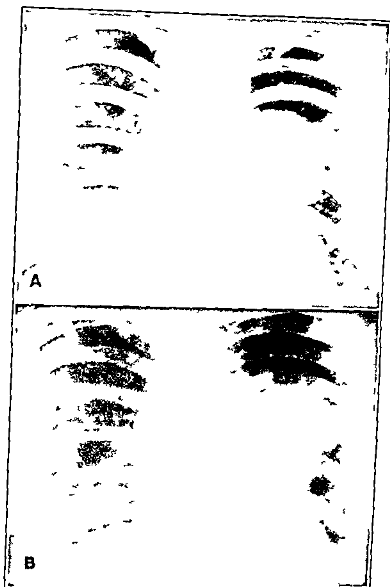


Fig. 409 — Aneurysm of the Pulmonary Artery

A There is a large rounded projection in the region of the left pulmonary artery. This area presents sharply defined smooth margins, is not lobulated, and on roentgenscopic examination shows expansile pulsations.

B Same patient two years later. The aneurysm has increased markedly in size.

Section X

THE PERICARDIUM

THE pericardium is a fibroserous sac which envelops the heart and the roots of the great vessels It consists of an inner serous layer and an outer fibrous layer which are reflected on each other forming a potential space termed the pericardial cavity This cavity is lined with endothelium and normally contains a small amount of fluid The fibrous or parietal layer of the pericardium and the mediastinal pleura are separated in the region of the lower portion of the heart and slightly above the level of the diaphragm on the left by a small pad of fat and loose areolar tissue which is termed the epicardial or apical fat pad Roentgenographically this is important in that there may be a small area of density continuous with the apex and left lower heart border which if its true nature is not recognized may cause the heart to appear larger than it really is The pericardium may be affected by inflammations neoplasms toxic metabolic and traumatic lesions

Pericardial Effusion (Figs 410 411)—The pericardial sac normally contains from 20 to 50 cc of fluid Rapid accumulation of fluid in the pericardium does not permit of stretching of the pericardium and cardiac tamponade ensues Gradual formation of fluid results in distension of the pericardial sac and it may become sufficiently distended to contain several liters Small amounts of fluid in the pericardial sac are not demonstrable by roentgen methods quantities of

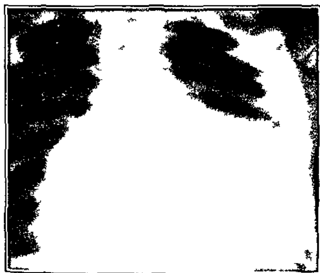


FIG 410—Pericardial Effusion

The heart shadow is increased in size to the right and left and is globular in shape No pulsations were demonstrable the heart shadow showing only a very light undulation on roentgenoscopic study

200-500 cc or more being necessary to produce characteristic changes With accumulations of 200 cc or more definite diagnosis is possible The heart shadow is enlarged both to the right and left It assumes a rounded globular shape and appears shortened The outlines of the individual chambers are lost and the normal alternating pulsations are replaced by a faint diffuse undulation or complete absence of movement However certain portions of the compressed heart may show vigorous pulsations The superior vena cava is widened The outline of the inferior vena cava is increased in width and appears convex There is posterior displacement of the esophagus With the patient upright there is increase

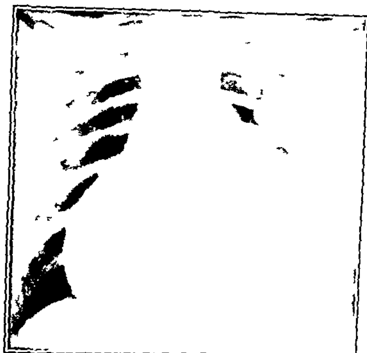


FIG 411 Pericardial Effusion

The heart shadow is rounded shortened and enlarged to the right and left The outlines of the individual chambers are absent The sharp delineation of the cardiac borders produce an appearance which suggests cardiac standstill and is due to the obscuration of the cardiac pulsation by the pericardial fluid

in the width of the lower portion of the cardiac outline In the recumbent position the supracardiac area is widened and the shadow of the aortic knob is flattened or obliterated The patient must be examined with the same target film distance if proper comparison is to be obtained Also sufficient time must be allowed to elapse after the patient changes position for shifting of the fluid to take place With massive pericardial effusion there is tremendous enlargement of the heart bilaterally the cardiac silhouette being rounded and extending to the margins of the chest wall There is no shift of the fluid hence no changes in the outlines with change in the position of the patient The cardiac pulsations are usually entirely absent and the heart appears motionless The character of the fluid cannot be determined by roentgen methods effusions hemorrhage and collections of pus resulting in similar roentgen densities Also the outline

of the heart cannot be visualized so that it is not possible to determine where the cardiac border lies

Enlargement and rounding of the heart shadow may occur in decompensation hence the changes in size and shape are not definite criteria for diagnosis. Similarly the change in the shape of the heart with shift of the position of the patient cannot be demonstrated in patients who are extremely ill or orthopneic. Kymographic studies may reveal decreased or absent pulsation and be of some aid in diagnosis. A very important aid in arriving at a conclusion [illegible] Marked change in size and shape in a relatively short time [illegible] evidence favoring the diagnosis of pericardial effusion. [illegible] effusion occasionally occurs and presents no typical roentgen findings. Diverticulum of the cardia is usually on the right side and may [illegible] The condition is congenital or due to traction and forms a [illegible] uniform sharply defined density continuous with the cardiac [illegible] of similar character may also be due to cysts, hemangiomata [illegible] dermoids or ganglioneuromata attached to the pericardium [illegible] metastatic neoplasms of the pericardium. Roentgen [illegible] anomalies is not possible. Cardiac dilatation which [illegible] tosis and diphtheria is also manifested by a rapid increase [illegible] rounding of the silhouette and marked weakness of the pulsation [illegible] the heart showing practically no movement [illegible]

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CONSTRICTIVE PERICARDITIS CALCIFICATION OF THE PERICARDIUM

Constrictive Pericarditis — The heart is usually [illegible] existing cardiac disease which had previously [illegible] border appears straight or irregular in outline and the pulsations [illegible] amplitude although in some cases there is a localized increase in the activity of the heart. The heart appears rigid and its configuration [illegible] varies only slightly during the two phases of respiration. Adhesions between the heart and pericardium lead to fixation of the heart which may be demonstrable by expiratory and inspiratory roentgenogram with the patient lying on either side or in the lateral projections. The supracardiac area may be widened and the aortic knob poorly visualized. The cardiophrenic angles may be shallow, flattened or obliterated

Calcification of the Pericardium Calcific deposits occur in the pericardium and are very important in diagnosis. The calcific depositions are flat or rounded smooth or irregular linear plaque like or in the form of rings and are adjacent to the heart shadow in all projections. Pericardial calcifications are most commonly found along the diaphragmatic surfaces of the heart and anteriorly over the right ventricle but may involve any portion of the pericardium and in some instances surround the inferior vena cava. The size shape density and

character of the plaques varies widely in different cases (Figs 412 413 414 415) By studying the patient roentgenoscopically at different angles a projection may be found in which the calcific deposits are demonstrated to be at the periphery of the heart shadow indicating the true nature and location of the densities Less than half of the patients with constrictive pericarditis reveal roentgen evidence of calcification of the pericardium The calcific shadows may be best demonstrated by films with the Bucky or body section roentgenography Kymography shows reduced amplitude of pulsations flattening or irregularity of the peaks of the waves and in rare instances increased pulsations over some portions of the heart (Figs 414 415) Differential diagnosis must include calcification of the heart valves within the heart walls the coronary arteries and the pleura

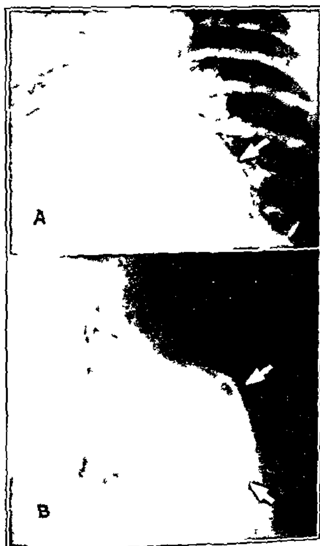


Fig 412 —Calcification of the Pericardium

A Sagittal projection There is a curvilinear area of calcific density adjacent to the left border of the heart characteristic of calcification of the pericardium

B Lateral view The calcification of the pericardium forms an arc which partially encircles the heart shadow

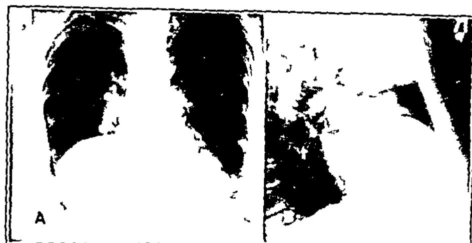


FIG 418 —Diverticulum of the Pericardium

A Sagittal projection There is a rounded sharply defined area of increased density adjacent to the heart shadow on the right The right heart border can be visualized through the density

B Lateral projection The relation of the area of density to the heart shadow is clearly demonstrated

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